

Engineering Record

A Weekly Journal Devoted to Civil Engineering and Contracting

PUBLISHED BY MCGRAW PUBLISHING COMPANY, INC.

Volume 69

NEW YORK, SATURDAY, JUNE 6, 1914

Number 23

Ten Years at Panama

ON May 4 was brought to a close ten years of American occupancy of the Canal Zone, the transfer of the canal property from the second French company to the United States having been effected May 4, 1904. The record has been one to be proud of, for in that time the waterway has been brought to practical completion. In fact, only two weeks after the rounding out of the decade the first commercial use of the canal had been witnessed, a tow of three barges, loaded with sugar, being transferred across the Isthmus for the American-Hawaiian Steamship Company. The tow started from Balboa, on the Pacific side, at 2:40 p. m. May 18 and completed the journey to Cristobal, on the Atlantic side, at 9 p. m. on the following day. With the work at Culebra proceeding at a goodly rate the use of the canal for an oceangoing vessel is not far off, for on May 19 the channel at the slide had a minimum width of 140 ft. and a minimum depth of 30 ft., the surface of the water in the cut being slightly below 85 ft. above sea level.

Exposition Engineering

WHEN the announcement was made that an international exposition would be held in San Francisco in 1915 to commemorate the opening of the Panama Canal it was natural to assume that the engineer would play an important part in building the temporary city to serve as the show place for the world's products. Engineers in the East and Middle West have realized in a vague way that the plans for the site were completed some time ago and that construction is now well advanced, but few of them have an adequate conception of the vast amount of work that has been required to provide suitable housing for the exhibits and to take care of the thousands of people who will visit San Francisco next year. On page 654 of this issue appears the first of a series of articles by A. H. Markwart, assistant director of works, describing the engineering features of the exposition. A large technical force has been required to design and supervise the work, and an organization diagram is printed to show the wide scope of duties and the division of responsibility among the various departments, which include those of construction, architecture, sculpture, color and decoration, landscape engineering, civil, electrical and mechanical engineering. While the planning of an exposition is, in a sense, a specialized field, many of the problems—such as building construction, sewerage, water supply, roads and pavements—are within the province of the city engineer, and the manner in which the solutions have been

reached at San Francisco is merely another instance of the engineer's invaluable service in the development of large projects.

Cement-Mill Dust

LARGE sums of money have been spent in the past, and are now being spent, to discover a method of preventing the escape of dust from cement plants. While in most cases there is no real damage from its escape, it is disagreeable to those living close to the mills. Quite a number of suits have been brought, and in many cases the cement companies, to avoid argument and be on good terms with their neighbors, have bought large tracts of adjoining land. That the companies have not been negligent in their efforts to prevent the nuisance is evidenced by the studies made, but the best talent so far has not been able to develop any means which can be unqualifiedly stated to have passed fully beyond the experimental stage. In this issue is described the dust-collection scheme used by the California Portland Cement Company. When it is considered that this plant was at one time shut down on account of the dust nuisance and that it is now permitted to run, the dust-prevention equipment has certainly enjoyed some measure of success. In general, the adoption of a process on a large scale will depend not only on dust-prevention efficacy but also on cost. There is little likelihood that as a conservation measure dust prevention will pay. It is more likely that it will be a direct charge on the cost of production.

Motorbus Operating Costs

ALTHOUGH the motorbus finds no such extensive use in this country as abroad, the number of these vehicles in the larger American cities has been increasing. Of course, the relative operating cost of the motorbus as compared with the street-railway car is the principal factor in the development of this form of traffic. In a paper presented last week at the National Conference on City Planning in Toronto John A. McCollum stated that in London, where the operation is skilfully managed, where the pavements are kept in excellent repair, and where the labor cost is low, the bare operating cost is less than 15 cents per bus-mile, and probably does not exceed by more than 10 to 15 per cent the cost per car-mile of the municipally owned surface railways. The excess cost is, however, more than offset by the lower interest charges on motorbus operation, and the total cost per bus-mile probably is less than the cost per car-mile. The relative vehicle-seating capacity used in this comparison is thirty-four for the motorbus and seventy-eight for the surface

car. This ratio brings the total cost per motorbus-seat mile greater than that of the car-seat mile. In London the life of motorbus equipment is estimated to be from five to six years, but in New York depreciation funds are provided sufficient to replace the vehicle safter three years' use. At the present time the cost seems to be sufficiently low to insure profitable operation in certain classes of service. These figures do not mean that the same relative ratios will obtain here. They do suggest, however, that with improved pavements the economics of the motorbus are worthy of the consideration of American urban transportation experts. It may be found that their field is restricted at present to runs for which the public is willing to pay a 10-cent fare.

Safety Overdone

ADDRESSING the master boilermakers at their recent convention at Philadelphia, Ivy L. Lee, executive assistant of the Pennsylvania Railroad, pointed out that, important as is the safety of the individual, reason and justice impose sharp limitations on the financial burdens to be put upon society to bring about such safety. As he states it, safety must be paid for out of income; otherwise principal is spent and resources are exhausted. Having done this, ordinary safety measures, obviously, cannot be paid for. Therefore it is only feasible to protect man up to a certain point and then make him look out for himself or assume the risks. Otherwise, as Mr. Lee says, we would never transport dynamite or even cross a street. Because families frequently burn to death in their homes, we would allow only "fireproof" construction, and would close buildings that were not fireproof. This would raise rents beyond the reach of the majority of dwellers. So it is with the railroads. Mr. Lee admits that "Safety first" should be the motto of every railroad, and surely the road he represents cannot be accused of laxity in this respect. But the motto of many legislative demagogues, "Safety at any cost," will bring disaster if carried to extremes. It is reasonable to demand that in new installations railroads not utterly bankrupt should use the safest designs known, and that they should carry out a program for replacing unsafe equipment as rapidly as possible. It is not reasonable to expect them to replace all wooden cars with steel at once, equip all their lines with block signals in a year, or eliminate all grade crossings forthwith at their own expense. The railroads—that is, the public who foot the bills—have not the money to pay for these things, and the mechanical safety obtained for individuals would be far more than offset by the social danger of financial paralysis.

Privately Financed Sewers

OF all privately owned public utilities sewerage systems have been the least exploited, although a number of cities in the Southwest in the earlier days granted franchises to sewer companies. It is, therefore, something of a novelty for the city of Vincennes, Ind., with a population of 15,000, to have its system constructed by private capital. A description of the plant appears on page 652.

By ordinary procedure the city could have constructed sewers under a council appropriation from the tax budget, by assessing property benefited or by a bond issue. The first method was practicable for short lengths of sewer only. The second method was considered impracticable under local conditions, as public opinion was somewhat at variance as to the relative importance of sanitary sewers, storm drains, flood protection, street pavements and other civic improvements. The third method, within the city's bond limit, would not have provided sufficient money. Finally an association was granted a franchise to build, operate, maintain and extend a system of sewers, fully defined as to extent and quality by plans made a part of the franchise.

Compensation was provided for by an annual rental paid by the city, or by a separate charge to patrons as with any other public utility. As a third option the city is permitted to purchase the system at a decreasing price fixed in the franchise. The rental basis has been selected by the city. The separate-charge plan comes into operation automatically upon failure of the city for sixty days to meet its obligation. The rental, amounting to about \$2 per capita, is such as to retire the bonds in twenty-five years, when the title passes to the city. Under the rental and purchase plans the city maintains and operates the system. Should the citizens be separately charged, the city bears no other relation to the association than is customary between a municipal government of any character and a public-utility corporation.

It is obvious that special care must be taken in drawing plans and specifications for work under such an agreement, in order that there may be proper flexibility and that the exact position of the city as regards engineering and inspection be clearly defined. At Vincennes a resident engineer, under the Board of Public Works, acted as its adviser as to changes in plans, had general oversight of the work, passed on materials and workmanship, and after making a final inspection recommended acceptance or rejection. The contractor supplied his own lines and grades and at the completion of the work furnished the city with record plans. The engineers state that the arrangement was reasonably satisfactory, but that it would be preferable for the city to have more complete control by furnishing lines and grades, making estimates of cost and maintaining more thorough inspection.

With these points carefully considered, this method of procedure may help to solve the financial end of sewer improvement for other towns where lack of funds prohibits the construction of the whole system at once,

or where a relatively expensive outfall may put too heavy a burden on the first section to permit proceeding by sections under the assessment plan.

Sanitary Engineering Innovations at Cleveland

AS a Mecca for sanitary engineers Cleveland promises to be most interesting during the next few years, for water-purification and sewage-treatment plants, following designs laid out to take advantage of testing-station results, will be well under way within the next six months. In addition, a trip to Cleveland will not be complete without an inspection of the garbage-reduction plant, which has been in operation for some years, but still adds new processes from time to time to increase its efficiency.

From the sewage-disposal standpoint there are at present indications that at least some values may be recovered from sludge, a proposition believed to be feasible by laymen since the accusations of Victor Hugo in "Les Misérables" with reference to the sewage of Paris. The one great obstacle in sewage treatment has been sludge disposal. At Cleveland two marked advances are to be made. First, it is proposed to reduce the area of sludge beds by dehydrating in glass-covered buildings of greenhouse construction. Experience indicates that from one-third to one-sixth of the usual area will do the work. Second, sugar presses operated by compressed air are to be utilized to reduce the moisture in the tank sludge from 85 or 90 to 65 per cent. Tests show that the pressed sludge may be made practically dry at the garbage-reduction plant at a cost of \$2 per ton and converted into a product similar to "tillage," worth at the present market prices \$4.50 per ton. Lack of ground area at the site of one of the disposal plants will make the greenhouse method very desirable. Imhoff sludge stored in a heated house during the past winter with no appreciable odor indicates that it can easily be handled indoors. Grit-chamber designs will likely be developed with the idea of keeping the velocities through them as nearly constant as possible under changing flows, thus preventing deposition of organic wastes and insuring removal of all grit.

The water-purification studies indicate that Lake Erie water can easily be treated to remove bacterial content and turbidity and reduce the hardness materially. Burning of sludge to recover the lime thrown down has been proposed. Perhaps this process may also lead to the utilization of the CO₂ given off for the removal of incrustations that may form on the sand grains of the filters. At any rate, a place has been provided in the filter design for sand treatment. Another possibility worthy of consideration if lime burning should be adopted is to store and subsequently utilize the CO₂ as an air wash.

Finally, the engineer will be interested in the latest garbage-reduction process whereby the liquid pressed from the digested garbage is condensed to the consistency of thick molasses in triple-effect evap-

orators and then added to the tankage, making a brown granular product having an odor not unlike cheap coffee. It has a market value \$1 or \$2 less than regular tankage. Thus the last of the reduction-process products has been made salable.

Cleveland, therefore, is likely to be much in the minds of engineers during the next few years. Possibly loyal citizens feel that it is her due, for it would merely be placing her in engineering ranks in the high place which one remarkable material progress has won in the estimation of laymen generally.

Electrical Power from Unmarketable Coal

SLOWLY but surely the transmission of electrical energy from low-grade coal is taking its rightful place in the conservation of natural resources. A noteworthy plant designed exclusively to utilize anthracite culm has been placed in service at Hauto, Pa., by the Lehigh Navigation & Electric Company. It is perhaps the most important development of its kind thus far inaugurated. Transportation of otherwise undeveloped energy by wire is the cheapest known method of putting the heat units latent in the refuse of the Hauto mine at the disposal of the consumer of power, and as the lines are designed for 110,000-volt operation it is significant that the possible useful radius of the plant includes the power markets of Philadelphia and New York, provided price and quantity meet the commercial situations in these great centers of population. Philadelphia is 73 miles and New York 98 miles from the station.

Only brief mention can be made of the more important features of the installation, but several of these cannot safely be overlooked by the engineer. Previously there has been no profitable market for this refuse coal, although its calorific value ranges from 9000 to 11,000 B.t.u. per pound. The cost of transportation of the low-grade material is the same as for the higher grades of anthracite, and on account of the large percentage of coal dust in the refuse it can be burned to advantage only in special furnaces. Unusual study has, therefore, been given by the designers of the plant to furnace conditions, and the performance of the various types of grates installed will be watched with interest, the plant having a mixed equipment, including both hand and mechanical firing. Coal and ashes are handled directly by cars without the use of conveyors or hoists. Large grate areas and combustion chambers, special facilities for air supply and thorough burning of the fuel and extra fire arches are among the attractive features of the station, whose design is upon the now well-established unit plan, with sufficient interconnection to provide a highly flexible scheme of operation. The economies of high-powered steam turbines and a large condenser installation are considered well worth the necessary investment cost, contrary to the thesis that a cheap fuel justified a cheaply built plant.

On its transmission side the Hauto development also contains many advanced features, though it is unnecessary to enumer-

ate them here. They have the same bearing upon the economic aspect of energy transmission that would pertain to a hydroelectric development.

With a yearly local output of culm sufficient to maintain a 100,000-kw. plant in continuous operation, the further development of the Hauto station is a foregone conclusion, assuming the logical business expansion to be anticipated in such an attractive location and with an engineering installation so carefully worked out.

Centralization of Power Supply

AS the readers of the Engineering Record are well aware there is a constantly increasing tendency in this country toward the gathering of electrical supply undertakings into groups supplied from one or more central stations. The recent reports of Merz and McLellan, the engineers entrusted with a report to the London County Council, shows that the world's metropolis has both acute need and a desire for reform. The territory of London from the standpoint of electrical supply is in an extremely backward condition. It is full of relatively small municipal and private enterprises, some of them exceedingly well administered yet as a whole falling short of what the supply of a great city should be. The situation is still further complicated by the fact that the private rights for the most part expire within the next fifteen or twenty years, so that the owners are not particularly keen about introducing large improvements which will revert to the benefit of the municipality. Still further, the London stations exemplify every variety of electrical distribution underground which has been imagined within the past twenty years.

Merz and McLellan in their report strongly recommend immediate preparations for a radical overhauling of the whole situation. They advise that some central body be empowered by Act of Parliament to undertake the bulk supply of electricity and the organization of a system to carry such a supply into effect. They advise the concentration of generating plants on the lower Thames, feeding London through a high tension three-phase primary network at 50 cycles per second. This method of supply lends itself with fair facility to meeting the demands of the various local systems. It is further recommended that in the interest of simplicity the present low voltage distributing networks should not be further extended, but should be supplemented by a new three-phase network to which load could be shifted or added in the development of new fields. The ultimate object, as the engineers point out, is the concentration of the production and the standardization of the distribution. If carried out the plan would almost infallibly end in the amalgamation of all of the undertakings in and about London into a single effective system. What headway can be made toward this desirable end remains to be seen. The fundamental principles are altogether right, yet to weld into a whole the fragmentary service now exist-

ing is a very serious undertaking. It involves clashing of private interests with local authorities jealous of their prerogatives. More than this, some of the existing plants are very efficient and well administered and have therefore comparatively little to gain unless generating costs can be greatly reduced. Yet as a whole the London situation is such as to make improvement imperative and the report of Messrs. Merz and McLellan is at least the first step toward the end sought.

Recognition of Extraordinary Construction Risks

THE construction of a connection between the present Interborough subway in Broadway and the new Seventh Avenue line in New York City is probably more difficult and dangerous than any similar work yet attempted. As a result more than ordinary consideration has been given the awarding of the contract; in fact, one contract was abrogated because the successful bidder had not the necessary experience to undertake so hazardous a piece of work. Moreover, the conditions are such that the hazards cannot be eliminated.

The work consists in rebuilding and slightly enlarging a four-track section of steel-bent and concrete subway about 450 ft. long in order to provide for a slight change of grade in existing tracks and to connect them with the new line. The five lowest bids in two competitions varied between \$304,000 and \$498,000, but most of the bids for the estimated quantities showed only a comparatively slight variation, the difference being mainly in the provision for indemnity against accident.

The conditions are extraordinary. The structure is fully occupied by four curved tracks on which ten-car express and six-car local trains are operated a large portion of the time at the rate of a train every 30 seconds. There are no large clearances, in some places only $\frac{1}{2}$ in. between the cars and roof and 6 in. laterally between cars and structure. Overhead there are electric-car tracks and a congested street traffic, with but a small depth of cover over the subway roof. The contractor is required to do the work without interference to traffic or damage to passengers or employees. There is no intermission, day or night, of traffic on the local track, and on the express tracks none except for a few hours after 1 a. m.

The character of the structure makes it impossible to arrange crossovers between the local and express tracks before the reconstruction is well advanced, so that work cannot be done inside the subway, and no clearance exists there for protection against exterior work. A considerable quantity of concrete and solid rock must be removed and the roof and walls of the present structure must be taken out while the present traffic is maintained. The difficulty of executing the work is considered greater than that of other subway changes where the actual cost of steel erection was more than \$200 per ton. Two temporary tracks must be built and renewed and three permanent

tracks shifted to new position while the street and trolley cars above and the roofs and walls of the subway are carried on temporary supports, which, in the event of derailment or other serious accident, might entirely collapse, causing a great catastrophe.

The gravity of these conditions is recognized by the contract requirements, which, in addition to the usual retained percentage of contract payments, provide for a bond of \$400,000 for the faithful performance of the work and for an indemnity bond of \$500,000 for the protection of the Interborough Rapid Transit Railway Company. The lowest bid was \$304,316, with an indemnity allowance of only \$12,000. Other low bidders allowed \$33,000 and \$135,000 respectively, while one of the high bidders allowed as much as \$200,000 for the same item. Later the low bidder admitted his inability to perform the work at a profit, but through his sense of honor was willing to fulfill his contract.

After serious consideration and in view of the almost certain loss to the contractor, the great danger and risk involved, and the natural tendency of the most conscientious constructors to economize on losing jobs, it was decided to reject all bids. Tenders were again called for, and the work was finally awarded for \$421,566, including an indemnity allowance of \$33,000, the same as was made by the same contractor for his previous bid. The former lowest bidder, who was glad to be released from his offer, did not compete in this case, and the next higher bidder, the Rapid Transit Subway Construction Company—which through its affiliation with the operating company could most advantageously do the work, and wished to do it for reasons of policy—bid \$468,038, reducing its previously included allowance for indemnity from \$135,000 to \$105,000. One of the other contractors, who also participated in both biddings, increased his original indemnity allowance from \$200,000 to \$228,000. This item may be regarded as purely an insurance item to cover possible damages and is wholly exclusive of labor or materials or estimated quantities.

The contract price is well within the chief engineer's tentative estimate and the contractor, a party of known responsibility and experience, promises to provide additional security by taking out a distributed insurance of \$50,000 for any one accident and \$50,000 for any one personal injury. Moreover, since he expects to complete the work in one year instead of the thirty-three months allowed—thus reducing in like ratio the percentage of risk—it is apparent that the Public Service Commission did well to readvertise the work. The construction should be well worth watching. The risks involved and the indemnities provided are of such a character that the contract may be said to have been let upon the courage and optimism of the contractor rather than on the specific quantities of work to be performed.

Although the award of the contract has been approved by the Public Service Commission it must be ratified by the Board of Estimate and Apportionment before construction may proceed.



Alfalfa Field Converted into a Waterlogged Alkali Flat

Drainage of Shoshone Irrigation Project

Waterlogging of Soil Reduced by System of Drains; Cost Data on Excavation with Dragline Scraper and with Ditch Excavator

By D. W. MURPHY

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RAPID spread of seepage and waterlogging of land following the beginning in 1908 of irrigation on the Shoshone project in Wyoming soon made it imperative that a system of drainage be constructed, and such a system was in operation in 1913, producing marked results in lowering the water plane. In constructing the drains both dragline excavators and a special trench excavator were used, and cost data for each are here presented.

The Shoshone irrigation project of the U. S. Reclamation Service is situated on the Cody branch of the Chicago, Burlington & Quincy Railroad, in the extreme northern part of Wyoming. It is in an almost truly arid region, the average annual rainfall being only about 6 in. The drainage of the project is consequently for the purpose of removing excess waters which have been brought to it by artificial means for irrigation purposes. The project derives its irrigation supply from the Shoshone River, the waters being impounded in the Shoshone reservoir, which is situated about 20 miles upstream from the irrigable area.

As stated above, irrigation on the project was begun in 1908. During that year a small area was brought under cultivation. This was gradually extended until it had reached about 20,000 acres during the season of 1913. The irrigable lands lie in a rather compact body. The northern and greater portion of them, comprising what is known as the Powell flats, is very uniform as to surface, with a general slope of about 25 ft. per mile. The southern portion adjacent to the river is more or less broken into benches laterally to the stream, but has a general slope with the stream about the same as that of the Powell flats previously mentioned.

WATER SUPPLY

Water is brought to the land by means of a main canal carried down practically along the line of greatest slope. The grades and velocities in this canal are controlled by means of a series of concrete drops. From the main canal water is carried out by a series of laterals which follow the contours as shown on the accompanying map.

The surface soil varies in different localities from a medium loam to a compact clay or gumbo, and ranges in depth, roughly

speaking, from 1½ to 5 ft. or more. The surface soil is quite universally overlaid by coarse gravel intermixed with sand and resting on a base of impervious sandstone or shale. The thickness of the gravel subsoil varies greatly, ranging, so far as known, from 10 to 30 ft. or more. It appears, also, from the records of wells that have been sunk through it that the gravel stratum is deeper over the upper portion of the irrigable area and that its depth gradually decreases in going down the slopes. In general the top soil is also thicker and more impervious on the lower portions of the slopes.

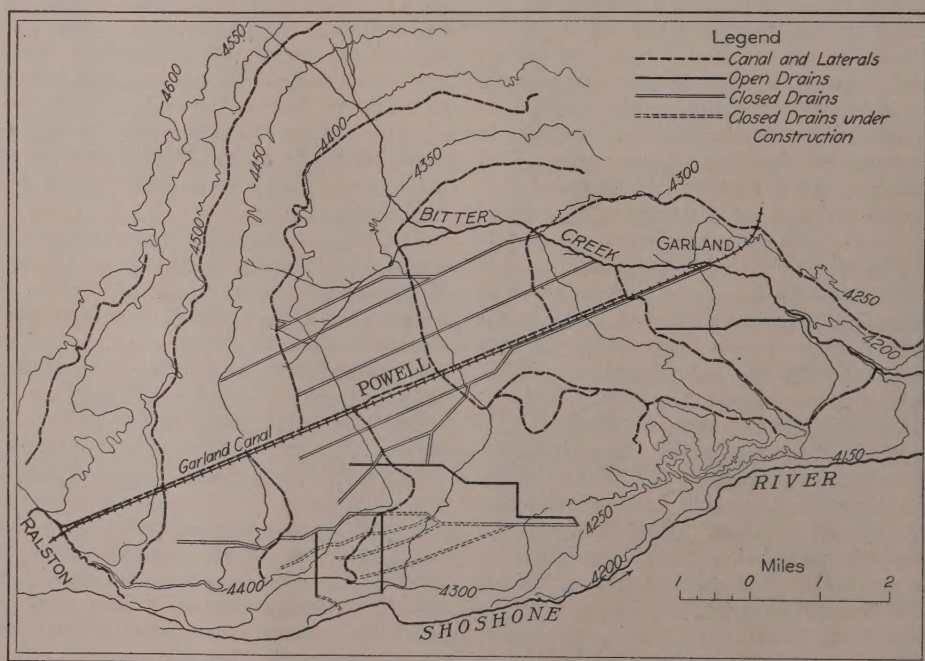
One natural drainage channel, known as Bitter Creek, crosses the Powell flats and terminates in the river below. This channel is comparatively shallow, seldom, if ever, extending through the impervious material in which it had been eroded. It served in its natural state to carry away the excess surface waters arising from occasional heavy storms, and since irrigation has been practised it has also carried away

a part of the waste from canals and surface losses from irrigation. On account of its steep slope it has been possible to lower this channel, where necessary, to make it serve as an outlet for deep drains with a minimum amount of effort.

Soil and topographic conditions of the project may be considered as favorable to seepage and waterlogging of land—this despite the popular and oft-quoted belief that a gravel subsoil will provide sufficient natural drainage to protect the lands. At the time irrigation was begun in 1908 the underlying gravel stratum was practically free from water. The domestic supply was obtained for the first settlers by sinking wells through the gravel and into the sandstone or shale so as to collect the small flow traveling over the surface of these impervious materials. By the end of the season of 1910, less than three years after irrigation was begun on the project, the gravel subsoil had in places become filled and the water table brought to the surface. In that year approximately 800 acres, out of a total of more than 16,000 irrigated, were affected so as either to render the lands unfit for cultivation or seriously to reduce the crop yields. During the season of 1911 the wet area doubled, and in 1912 more than doubled again. This condition with the water table steadily rising over nearly the entire irrigated area made it evident that an efficient and comprehensive drainage system must be constructed or large portions of the project must be abandoned.

EXCESS WATER

The excess water in the soil was due in part to losses from the canals and laterals and in part to waste and underground losses from irrigation. Most of the canals are excavated in gravel and are more or less porous, which results in a continuous loss from them during the irrigation season. Conditions are also favorable for excess irrigation without producing surface waste on account of the porous sand and gravel subsoils. When the application of water is heavy or is continued for a considerable period of time, a part of it passes entirely through the top soil and is absorbed by the gravel below. There thus results underground losses or waste of water from irriga-



Topography, Main Canal, Laterals and Open and Closed Drains of Project

tion which cannot be readily detected by the irrigator. This underground waste, together with losses from canals, resulted in a filling of the subsoil gravels to such an extent that water finally rose to the surface. The first seepage appeared in the slight depressions or where the steep upper slopes changed to flatter ones below. This shows that the formation or change in grades at such points offers resistance to the percolation or flow of the ground water, thus forcing it to the surface. It was found also that where the top soils were thin or of a porous nature, water rose through them more quickly.

FIRST DRAINAGE WORK

The first drainage work undertaken on the project was begun in the fall of 1911. This work consisted of a system of open ditches designed principally for relieving individual seeped areas. Five drains, having a total length of $7\frac{1}{2}$ miles, were constructed as open drains partly by contract and partly by United States forces after the contractor had failed to complete the work. It became evident soon after this work was begun that on account of the rapid spread of seepage it would be necessary to design and construct drainage works sufficient to effect a general lowering and control of the ground waters over the greater portion of the irrigable lands of the project. In designing a comprehensive system for effectiveness of operation and economy of construction, it was necessary to give careful consideration to locations, depths, capacities, and kinds of drains to be used.

The locations were chosen from a consideration of both the subsoil and the topographic conditions. First consideration was given to locating the drains in water-bearing materials; that is, in materials which would yield a ready flow; and the second, to locations that would be effective in lowering the water plane over the greatest possible area. These considerations gave rise to two distinct types of drains. On the Powell flats, where the ground waters were generally high, drains were placed at more or less regular intervals, in order to effect a general lowering of the water plane over the entire area. Their direction was generally down the line of greatest slope. On the benches drains were located at or near the foot of the steep slopes for the purpose

of intercepting the water which percolated down these slopes and prevent its reaching the bench below. In all cases careful investigations were necessary to locate the drain in both porous and water-bearing materials.

In determining the depths an attempt was made to put the drains low enough to hold the water plane below the point from which capillary action would bring any considerable quantity of water to the surface. Some consideration was also given to providing storage space in the subsoils enough to take care of a part of the losses during the irrigation season, without raising the water plane to a dangerous height. This it was expected to accomplish by placing the drains deep enough to draw out a part of the excess waters during the non-irrigating season. By making them operate during all or a greater part of the year the required capacity is also reduced. In a few cases it was necessary to resort to deep cutting in order to reach porous or water-bearing materials. The depths required to meet the above-cited conditions, so far as it seemed feasible, ranged roughly from about 8 ft. as a minimum to about 11 ft. as a maximum. In a few cases this minimum was not reached, while in a few others the maximum was exceeded.

CLOSED DRAINS

The closed type of drain was adopted, first, for the reason that it requires little or no maintenance when properly constructed, and, second, on account of its greater efficiency due to the grade or bottom of the drain remaining always at the same elevation. With open drains in earth there is a constant tendency for them to become filled at certain points, thus causing water to stand in them, a condition which decreases the effective depth. The first cost of closed drains where large capacity is not required is not greatly in excess of open ones; that is, provided the value of land taken, cost of bridges and all other things of this character are considered.

With the closed drains it was necessary to choose some basis for determining the probable flow of each and the consequent capacity and size of pipe required. On account of experimental data on this point not being available, this had to be determined largely from theory and assumptions as to probable water losses from irrigation and other causes. Roughly the drains were designed with a capacity large enough to discharge from 30 to 40 per cent of the total amount of water applied to the land, provided they operated at or near their full capacity during a period of ten months out of each year, which is approximately twice the length of the irrigation season. In this connection it should be stated that it was not expected that the drains would operate at or near their full capacity during the non-irrigation season, or that the total quantities they would have to discharge would exceed from 20 to 30 per cent of that applied to the land. This was based upon the assumption that a reasonable use of water would be practised. Results of one year's operation show that the drains were operative throughout the entire year and that they discharged approximately their full capacity for only a few days immediately following the period of heaviest irrigation.

The construction of tile drains was begun in August, 1912, the excavation of trenches being done by means of a Lidgerwood drag-



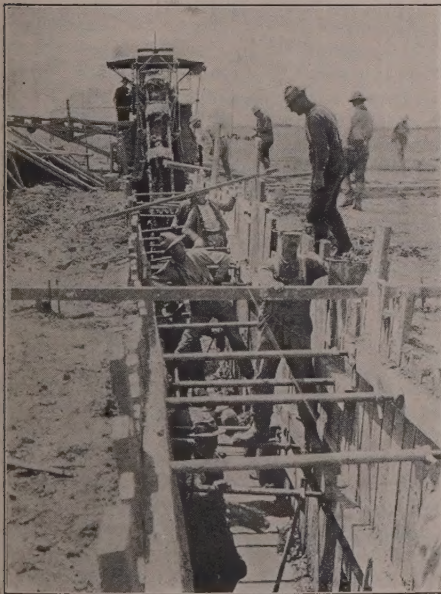
Dragline Scraper Used on Some of the Work

line excavator of 1-yd. capacity. On account of the heavy underlying gravels, which in places contained boulders up to 10 in. or more in diameter, it at first seemed questionable if the material could be handled by the ordinary trenching machine. In October, 1912, however, an Austin "No. 00 Special" trench excavator was put on the work. These machines were operated continuously, two shifts per day, until near the end of the year, when work was suspended on account of the ground being frozen too deep to make excavation practicable. At the time of suspending work 41,940 lin. ft. of tile had been placed.

In the spring of 1913 work was again resumed with the two machines, and in June a second dragline excavator was started. During the season of 1913, 98,545 lin. ft. of tile drains were constructed with the three machines. This makes a total of 140,485 ft., or nearly 27 miles, of closed drains built up to the present time. In addition to this, 3045 ft. of open outlets for the tile drains were constructed.

The drain tile used ranges in size from 10 to 18 in. in diameter. It is vitrified, partly salt-glazed pipe and is made in 2-ft. lengths without bells. In placing the tile in the trenches the joints were laid as close as possible and a strip of tar paper about 3 in. wide and two-thirds of the circumference of the pipe in length was placed over each joint. The purpose of these coverings is to force the water to enter the pipe through the bottom portion of the joints and lessen the chances for sand and other fine materials being carried into it. Trap boxes, each approximately 4 ft. square and set down 18 in. below the bottom of the pipe, were placed at intervals of about 1000 ft., the function of these boxes being to provide means for inspection of the line and also to catch any sediment carried into the pipe. During construction they were cleaned at frequent intervals, sometimes as often as once a day. By this means the pipe was soon cleared of the sediment carried into it during and immediately following construction. Measuring weirs for showing the amount of discharge were provided at the outlet of each of the lines.

The principal difficulties encountered during construction were holding the trenches open until the pipes were in place and keep-



Using Trench Excavator in Wet Material

ing them on grade and line where soft materials were encountered. Over a considerable portion of the area the water plane, as heretofore stated, was at or near the surface of the ground, and the excavation was all wet. Where the underlying material was of coarse gravel the banks could generally be held by bracing at frequent intervals, and no difficulty was experienced in holding the tiling on grade and line. Where a sand substratum was encountered, however, tight sheeting was necessary to maintain the trench open to grade. Frequently the lower portion of the excavation consisted of liquid mud which had to be pumped or bailed out. Here it was generally necessary to lay the tiling in wooden saddles to prevent its settling and being pushed out of line during the process of backfilling. Where a heavy flow of water was encountered in the sand, as was frequently the case, the upward pressure was sufficient to lift the tiling off grade. To prevent this, saddles were also placed on the top of the pipe and an earth load was placed upon them.

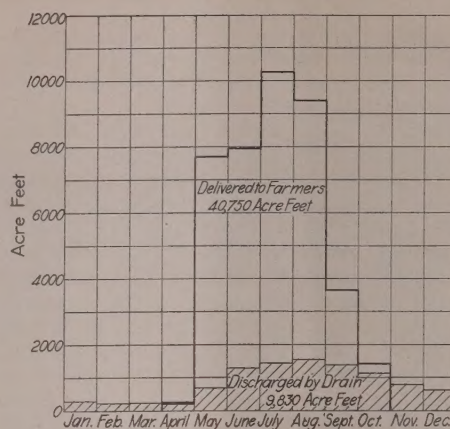
RELATIVE EFFICIENCY OF MACHINES

The relative efficiency and cost of work with the two types of machines depended somewhat on the kind of material to be handled. Where the banks could be made to stand with a moderate amount of bracing the trenching machine was capable of making the better progress. On account of the smaller amount of material necessary to be handled with it both in excavation and backfilling, the cost per linear foot of line was generally less than with the dragline excavator. In very bad material the dragline possesses advantages, on account of its adaptability to excavating a wide trench and to depositing the material at a greater distance from the excavation. It is possible, also, with the dragline to continue excavation in one place as long as it is desired. Consequently grade can be reached if the trench is cut wide enough, provided the material is not in a semi-fluid state. In some cases a trench 30 ft. wide on top was excavated before a depth of 10 ft. was reached, and frequently sheeting had to be used in such a trench in order to take out the last foot or so of liquid mud.

In reasonably good material it was possible by means of the dragline to excavate a trench having a minimum bottom width of between 3 and 4 ft. and an average width of about 6 ft. To accomplish this a specially built long and narrow bucket was used.

The most economic method for doing this work depends upon the character, amount and distance from the trench of the material. Where the yardage is small and the excavation deposited near the open trench, some form of grader operated by teams is a very efficient method for most materials. Where, however, the material is of a refractory nature, such as sticky clay or adobe, or where it is deposited at some distance from the trench, some form of dragline seems best adapted to handle it.

The lengths, sizes of pipe, methods of construction and unit cost for the three completed tile lines are shown in the tabulations. These costs include depreciation of machinery and all miscellaneous and overhead charges. In making a comparison of costs with the two types of machines it should be noted that an effort was made on beginning the work to place the trenching machine where it seemed probable least difficulty might be encountered from caving banks. This may in a measure account for



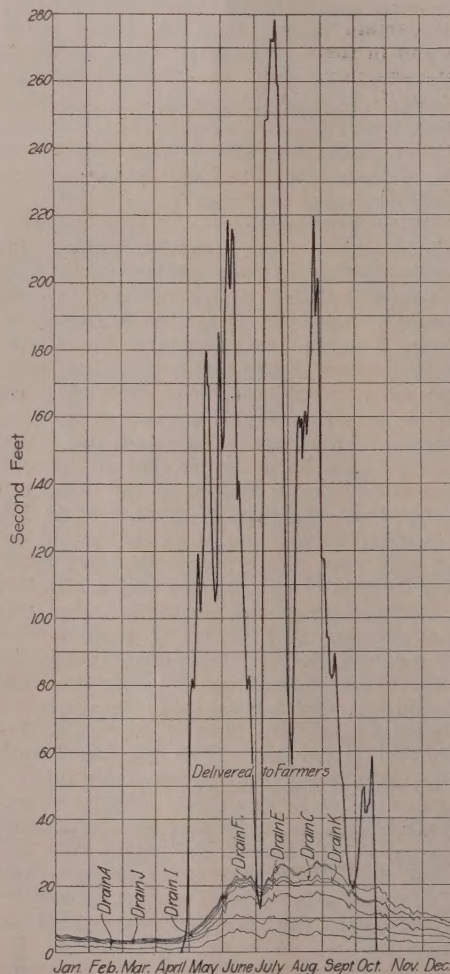
Mean Monthly Delivery and Discharge

the variation in unit costs, but to what extent cannot readily be determined.

RESULTS OF DRAINAGE SYSTEM

The amount of water discharged in 1913 by the drains, together with that delivered to the land, is graphically shown by the curves. The curves of daily mean flows are of special interest in showing the time required for the drains to respond to an increase or decrease in the amount of water delivered to the land. The curve showing the mean monthly discharge of drains in addition to the general results indicates the quantity of water carried out during the non-irrigating season, or, in other words, the storage space provided in the subsoils.

The maximum discharge of any one drain was 7.78 sec.-ft., which was discharged by drain I during the latter part of August and



Daily Delivery and Discharge of Water

first part of September. This was equal to 0.94 sec.-ft. per mile of drain constructed at that time. One open drain A, a little more than 2 miles long, and excavated in rather loose gravel, discharged a maximum of 7.44 sec.-ft., or about 3.7 sec.-ft. per mile of drain. This drain was completed during the year 1912 and operated throughout its full length the entire year of 1913. During the year it discharged 2435 acre-ft., which

DRAIN I—EXCAVATED BY TRENCHING MACHINE; BACKFILLED BY RECLAMATION GRADER DRAWN BY TEAMS

Size of pipe, in.	Length of pipe, lin. ft.
10	7,803
12	15,180
15	13,085
18	13,495
Total	49,563

Cost per Linear Foot

Excavation	\$0.475
Laying tiling and covering by hand to a depth of 18 in.	.162
Backfilling to surface	.117
Average cost of tiling delivered at works	.343

Total \$1.097

DRAIN J—EXCAVATED BY DRAGLINE; BACKFILLED WITH WESTERN SPECIAL GRADER AND FRESNO SCRAPERS DRAWN BY TEAMS

Size of pipe, in.	Length of pipe, lin. ft.
12	10,795
15	14,962
Total	25,757

Cost per Linear Foot

Excavation	\$0.749
Laying tiling and covering by hand to depth of 18 in.	.195
Backfilling to surface	.403
Average cost of tiling delivered at work	.305

Total \$1.652

DRAIN K—37,645 FEET EXCAVATED BY DRAGLINE, 3,845 FT. BY TRENCHING MACHINE; BACKFILLED BY RECLAMATION GRADER AND ALSO BY DRAGLINE

Size of pipe, in.	Length of pipe, lin. ft.
10	10,440
12	17,950
15	11,933
Total	40,323

Cost per Linear Foot

Excavation	\$0.684
Laying tiling and covering by hand to depth of 18 in.	.162
Backfilling to surface	.315
Average cost of tiling delivered on work	.283

Total \$1.444

is equivalent to an average flow of 3.37 sec.-ft., or about 1.6 sec.-ft. per mile. Drain J, also constructed during 1912, reached a maximum flow of about 4.5 sec.-ft. during 1913 and discharged during the year 1913 acre-ft., an equivalent of an average flow of 2.7 sec.-ft., or about 0.6 sec.-ft. per mile.

The effect of the drains has been a general lowering of the water plane over the area tributary to them. The amount of this lowering varies in different localities from 2 to 6 ft. or more. There is a marked difference in the rate of lowering of the water plane on different areas, due to character of soil and the presence of more or less impervious dike-like deposits which prevent a free percolation to the drains. In general, on those areas where drains have been completed the lowering of the water plane is already sufficient to permit the lands being again brought under cultivation.

It is expected that during the irrigation season a rise in the ground waters over portions of these areas will be experienced, and that possibly additional branch drains may be required to protect small tracts from further occurrence of seepage. Whether or not this will be the case and how much additional construction will be required will depend largely upon whether there is careful use of water in irrigation and prevention of excessive losses from canals.

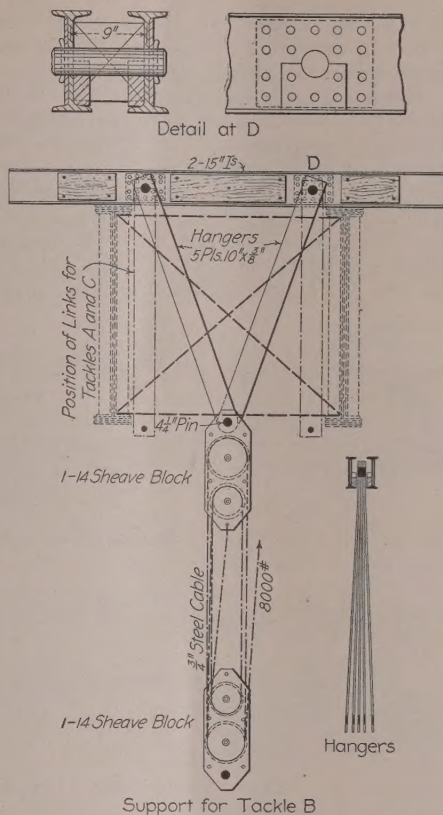
Hoisting Wrecked Locomotive from River Bottom

Falsework Towers and Lifting Girders, to Carry Five Sets of Heavy Tackles, Raise Weight of 256,000 Pounds

NOT only have the resources and equipment of the bridge engineering department of the Canadian Pacific Railway dealt successfully with many difficult and important structural problems connected with the 7000 miles of track under its system, but they have been applied with equally good results to unusual work of a character not generally recognized as strictly bridge engineering. A 128-ton wrecked locomotive buried in the mud of the river bed was hoisted above water level by tackles suspended from a temporary plate-girder span on falsework towers that was installed by the bridge department where ordinary methods of raising the wreck would have been useless.

A derailment on the original wooden trestle bridge at Eastman on the Sherbrooke section of the Eastern division of the Canadian Pacific Railway allowed the locomotive and tender to plunge through the floor into the river, where it alighted right side up and sank until only the top of the cab projected above the mud. It was raised by the members of the bridge department, who constructed in the line of the bridge two two-bent wooden-pile falsework towers clear of each end of the locomotive, and seated on them a pair of 90-ft. plate girders, 8 ft. deep, braced together with laterals and sway frames. A sort of gallows frame or hoisting tower was thus constructed and from it heavy tackles were suspended, attached to the locomotive, and operated by ordinary wrecking cars at both ends. They lifted the locomotive and tender, which, together with the mud, weighed about 256,000 lb. They were hoisted 21 ft. in a few minutes and remained suspended in the tackles while a falsework trestle was constructed under them, and a track laid on it, to which the locomotive was lowered to rest on its wheels, and from which it was promptly hauled away to the repair shop.

The locomotive was so deeply embedded in the mud that an armored driver was unable to place the wire-rope slings under the boiler and trucks. One of the bridge crew dived without armor and by the aid



150,000-Pound Capacity Locomotive

of a long bent pole succeeded in adjusting the necessary slings so that the locomotive was hoisted safely and without much difficulty.

Care was taken to empty the boiler of water and to break the tanks in the tender so as to empty it also, in order to reduce the suspended weight as much as possible.

CONNECTIONS FOR TACKLES

The weights supported by the tackles at A, B and C were estimated at 60,000, 150,000 and 45,000 lb. respectively. The tackles at A and C were rove with thirteen parts of $\frac{5}{8}$ -in. steel rope, while the center tackle at B had twenty-nine parts of $\frac{5}{8}$ -in. steel rope rove through two fourteen-sheave tandem blocks, having a calculated strain of 8000 lb. on the fall line.

The tandem blocks were attached by a special multiple-link connection to the trans-

verse jigger beam, which rested on the top flanges of the overhead girders. Each of the two inclined links consisted of five $10 \times \frac{3}{8}$ -in. plates 11 ft. long, pin-connected at both ends. The lower ends of the plates were separated to fit between the cheek plates of the block, and the upper ends took bearings close together on a $\frac{1}{4}$ -in. pin passing through the webs of the girder beams.

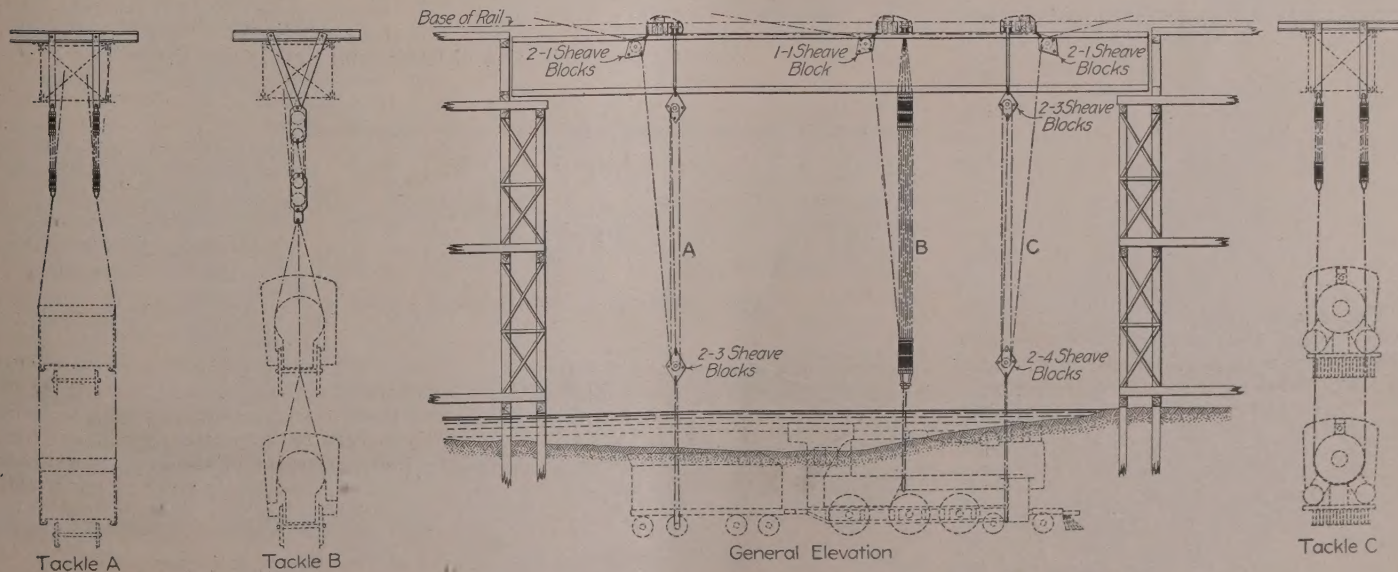
The webs of the jigger beams were reinforced for pin bearing by outside riveted plates $\frac{1}{2}$ in. thick with full holes and by inside cast-iron blocks $2\frac{1}{2}$ in. thick with half-holes, with their lower edges fitted to the I-beam flanges. The jigger beams each consisted of a pair of 15-in. I-beams bolted together with wooden separators.

The attachment for tackles A and C consisted of pairs of vertical $10 \times \frac{1}{2}$ -in. plates pin-connected to the beams, as already described, and shackled at their lower ends to the upper tackle blocks. The lower tackle blocks were shackled to hook bars engaging the edges of the tender tank and to slings passed under the boiler frame.

The work was planned under the direction of C. N. Monsarrat, who was then bridge engineer, and since succeeded by P. B. Motley.

Hardening an English Water Supply

BECAUSE the water supplied to Birmingham, England, is so soft that disinfection of lead pipes was feared, finely powdered chalk in amounts varying from 1 to $1\frac{3}{4}$ grains per imperial gallon is introduced at the head of an aqueduct discharging 73 miles away. The "Surveyor and Municipal and County Engineer" describes the process. A vessel is provided into which is put the quantity of chalk required for adding the fixed proportion for the time being to the water to be discharged into the aqueduct during the following twelve hours. The chalk is then mixed with water. A vessel is provided with a stirrer operated by means of a water engine. The same engine operates an endless band on which are small cups, each of which picks up a small quantity of the mixture and discharges it into a launder, where it mixes with the tail water from the water engine. This further dilutes it, and it is then discharged into the aqueduct.



Arrangement of Falsework, Tackles and Slings for Hoisting 128-Ton Wrecked Locomotive

Comparative Costs of Different Designs for Piers

Digest of Alternative Bids on Six Types Obtained by Department of Wharves, Docks and Ferries, Philadelphia

RADICAL differences of opinion as to the relative economy of different types of pier design led the Department of Wharves, Docks and Ferries of Philadelphia to ask bids on five different designs for two steamship piers to be built at that port. All were based on the use of wooden piles, the waters at Philadelphia being free from marine borers. In addition to the five designs, a sixth design and bid was received from one contractor. In each case the pier was 551 x 180 ft., with an area of 99,200 sq. ft., but two of the designs included a bulkhead shed 306 x 34 ft., increasing the area to 109,700 sq. ft. In each case, also, two railroad tracks ran down the center of the pier, with the top of rail 3 ft. 6 in. below the platform level. The deck slabs were all designed for a live load of 600 lb. per square foot and the column bases for a second-floor live load of 300 lb. and a total roof load of 70 lb. per square foot.

In type A double rows of piles in transverse bays, on 20-ft. centers longitudinally, are cut off just above low water and covered with a light timber deck on which are built concrete walls about 11 ft. high. These support a system of reinforced-concrete floorbeams and slabs on which the deck paving is laid.

In type B piles on 5-ft. centers longitudinally and transversely are cut off just above low water and covered with a heavy deck on which earthfill is placed between the side walls, which are also carried on the platform. The pavement is laid with a 6-in. concrete base on the fill.

Type C modifies type B by eliminating all piling and platform except as needed to support the side walls, tracks and column pedestals, filling down to the ground line and retaining the fill by wooden sheet piling braced against the platforms carrying the side walls.

The alternate design submitted by the one contractor is similar, except that concrete sheet piles with metallic interlocking are substituted for the wooden sheet piling, and the side walls are carried on concrete instead of wooden piles.

In type D the 10-in. reinforced-concrete floor slab is carried directly on the tops of the piles, which are left at the proper height and are in bents 10 ft. on centers.

Type E resembles type A, but substitutes concrete pedestals and deep reinforced-concrete transverse beams for the transverse walls.

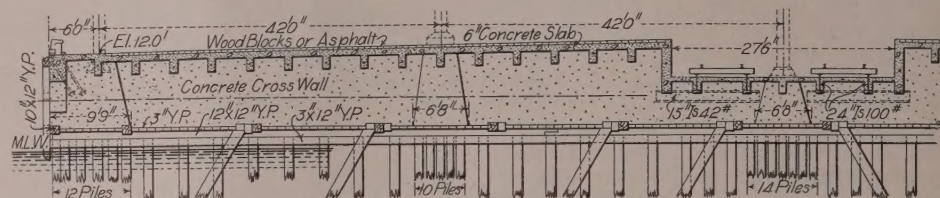
The bids on types D and E include the bulkhead shed, and other peculiar conditions call for adjustments to bring the figures to the same basis as the bids on the other types. Deck paving was not included in the proposals for these two designs, and using the lowest bid for such paving where it was included, a cost of 18 cents per square foot should be added. Also a change in the specifications for piles between the first and second biddings would call for an addition of 10 cents per square foot to bring types D and E to an equal footing with the others. The bid for type C calls for \$25,000, or 25 cents per square foot, for riprap to protect the sheet piling. On the other hand, it is believed that \$10,000, or

10 cents per square foot, would be spent in cobble or gravel fill around the piles in the other types, and this is not included.

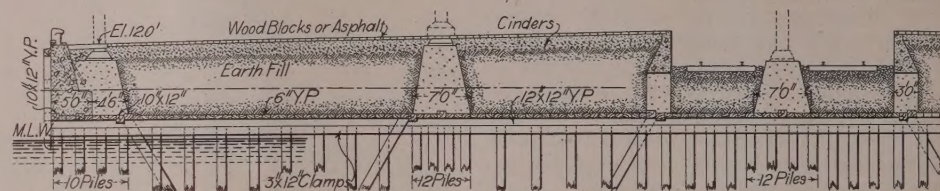
Making these adjustments, type D is found to be the cheapest, at respective minimum and maximum costs per square foot of \$2.53 and \$2.92, type E coming second at \$2.61 and \$3.01. The corresponding minimum and maximum figures for types A, C and B would be \$2.87 and \$3.73, \$3.02 and \$3.58, and \$3.07 and \$3.53. The single alternate bid figures \$3.225, the unit prices

for several of the items being considerably above the low bids for the same items.

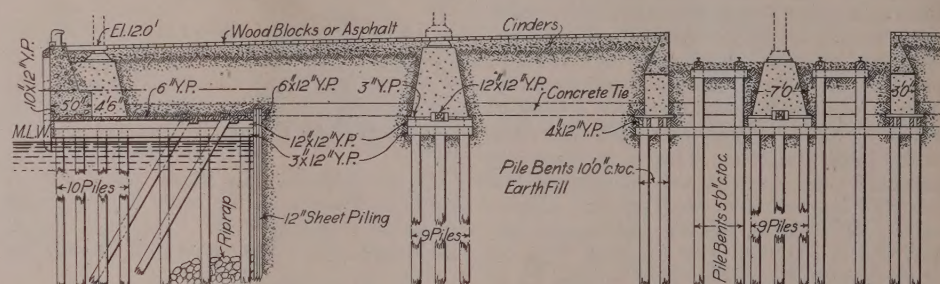
The ruling considerations in the designs were, first, practical permanency of construction, and, second, as great a degree of economy as was consistent with permanency and stability. In the absence of borers all of the types are considered permanent except type D, the top of which would require complete renewal in ten or fifteen years. It was originally thought that the upper portion of such a design would be



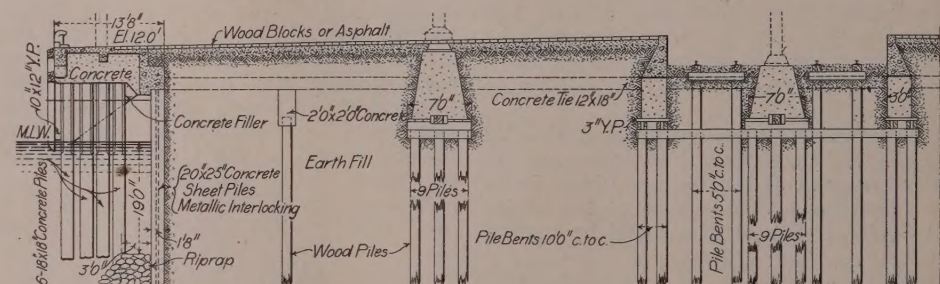
Type A—Double Rows of Piles—Bents 20 Feet on Centers



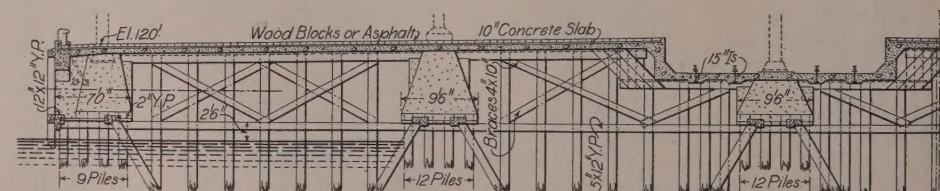
Type B—Pile Bents 5 Feet, Column Bents 20 Feet on Centers



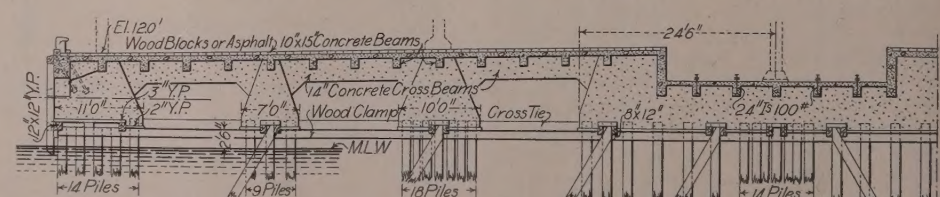
Type C—Transverse Bents Spaced 20 Feet Center to Center



Alternate Design—Spacing of Bents Same as for Type C



Type D—Pile Bents 10 Feet, Column Bents 20 Feet on Centers



Type E—Transverse Bents Spaced 20 Feet Center to Center

Transverse half-sections, with superstructures omitted; general dimensions on type A apply to all; depth of dock, 35 ft.

Six Hundred Transit Shots in Eight Hours

Record Speed for Topographical Work Attained by Motion Study and Ambidextrous Efficiency

AS many as 600 side shots have been taken in one eight-hour day by a transitman in the topographical surveys made by the Morgan Engineering Company, of Memphis, Tenn., for flood prevention and the drainage of lowlands in the Mississippi River valley. This record, twice as good as the average, has been attained by great rapidity of action and by adopting a procedure of the fewest and simplest possible movements, a fixed position, and the use of both hands simultaneously and interchangeably for making instrumental adjustments, as indicated in the accompanying illustrations.

Ordinarily this transitman maintains a fixed position, sighting both right and left and using right and left eyes respectively without moving his body. He has two rodmen, one stationed on either side, instead of having them in front and rear, and as he



Fig. 1

readily renewable and that a material saving in first cost could be effected by its use. The difference in bid prices, however, as compared with type E was deemed insufficient to warrant the adoption of the less permanent type.

Of the permanent designs type E is thought to be the most economical for the width of pier under consideration, and presumably for narrower ones. For widths in excess of 200 ft. the figures point to type C as the most economical. As the department favors wide piers—300 ft. and upward—it is expected that type C will be generally used in future work.

VERY DEEP DIAMOND DRILL HOLES, extracting cores of $1\frac{1}{8}$ -in. minimum diameter, have recently been bored with Sullivan C and B type machines. A prospecting hole at Taber, Alberta, Canada, was bored to a depth of 3003 ft. with considerable difficulty on account of soft and caving ground and required no less than 10,478 ft. of 2, 3 and 4-in. casing. A hole 3200 ft. deep was bored near Bisbee, Ariz., and one 3265 ft. deep at Republic, Mich.



Fig. 4



Fig. 3

takes his side shots he uses both hands interchangeably for manipulating the instrument and takes care usually to hold the note book in his left hand and preserve the place by the insertion of one finger, still leaving that hand free for the instrument work.

In the first position the transitman sights with the right eye, directs the instrument with the left hand at the sun shade and clamps the horizontal axis with the right hand. In the second position the left hand is used for adjusting the focusing screw and the right hand for adjusting the gradient screw. In the third position the instrument is turned 90 deg. in azimuth, with the vertical circle toward the observer who takes the reading, his left hand being on the reading glass and the right hand turning the instrument by the upper motion tangent screw.

In the fourth position the observer sights with his left eye, directs the telescope with his left hand on the sun shade and clamps the horizontal axis of the telescope with his right hand. In the fifth position the right hand is used for operating the focusing



Fig. 2

screw and the left hand for operating the gradient screw simultaneously. The instrument is then turned 90 deg. in azimuth and readings are repeated as before.

These operations are rapid and accurate and are apparently made with less effort than those of the ordinary observer, and less danger of disturbing the instrument.

SPEEDING UP a machine shop by means of an electric drive has been proved possible at a shop maintained by the city of Chicago for repair work on pumping and other apparatus for the water department. Formerly the shop was driven by a slide-valve steam engine through intricate line shafting. No-load tests made showed that 53 per cent of the power generated was required to drive the line shafting and idle pulleys. During the year 1913 a motor-generator set was substituted for the steam engine, with the result that the line-shaft losses have been reduced from 53 to 10.8 per cent. Furthermore it has been possible to increase the speed of the line shafting a third, and the men in the shops have unconsciously speeded up correspondingly.



Fig. 5

Cement Company Recovers Kiln Dust to Prevent Damage to Orange Crops

Patented System of Gravity Separation and Washing at California Mill Collects Daily Average Quantity of 75 Tons of Fine Material

By T. J. FLEMING

Secretary and General Manager, California Portland Cement Company, Los Angeles

RECOVERY of dust from the waste kiln gases of the Colton plant of the California Cement Company is accomplished by a patented system of gravity separation and washing installed during 1911 in connection with five $7\frac{1}{2}$ x 125-ft. rotary kilns. Other units have since been added. The dust-collecting system is the outcome of a lawsuit brought against the cement company by orange growers who contended that their fruit was being spoiled by the dust from the plant. This article will deal with the dust-collecting plant for five $8\frac{1}{2}$ x 150-ft. kilns, each with a capacity of 750 bbl. per day. The total amount of dust recovered per day is 75 tons.

A draft in the cement kilns is produced by fans located between the kilns and dust house. A large part of the dust is then captured in the dry state by reducing the velocity of the gases, and the remainder of the dust in the gases, together with the noxious gases, is washed out by sprays and sheets of water. The gases from each kiln are drawn by individual fans through separate flues and are discharged directly into the dust house. The flues first rise, then curve over and slope downward toward the fans. The flues are $6\frac{1}{2}$ ft. in diameter and about 180 ft. long. Each flue is provided with necessary expansion joints and is lined with firebrick for a distance of about 20 ft. The fans are of special exhauster type, 5 ft. wide and with wheels 10 ft. in diameter. They are made by the B. F. Sturtevant

Company. They are equipped with water-cooled bearings, and operate at a speed of 145 to 150 r.p.m., being driven by 40-hp motors.

The volume of gases discharged from each kiln when operating at 750 bbl. capacity per day is approximately 25,000 cu. ft. per minute; the temperature is 900 to 1000 deg. Fahr. The temperature of the gases at the fans does not exceed 800 deg., and the velocity in the flues does not exceed 15 ft. per second. The fans have been installed to manage an excess of gases in case of leakage of air and also for the necessity of drawing cold air through the kilns when they are being relined or repaired.

DRY AND WET CHAMBERS

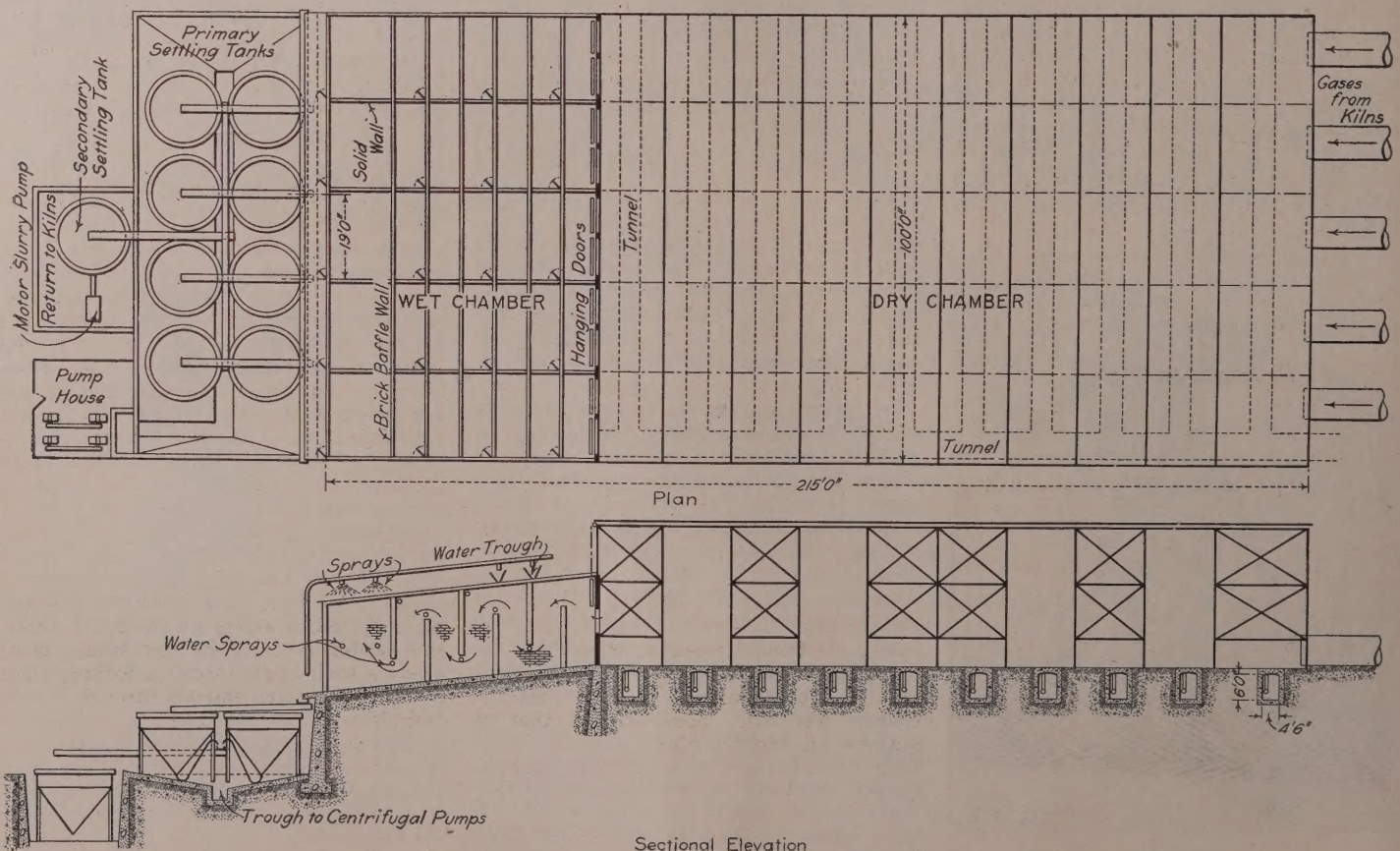
There are two departments to the dust house—the dry chamber and the wet chambers. The former, which receives the gases directly from the fans, is one large room, 100 ft. wide, 155 ft. long, and with an average height of 31 ft. The dry chamber is of steel-frame construction, the sides and roof being covered with galvanized corrugated iron in order to assist radiation as much as possible. There are ten cross-tunnels leading to a longitudinal tunnel running lengthwise with the dust chamber. In these ten tunnels are located screw conveyors with steel troughs and spouts. Gates lead from the floor above into the cross-conveyors for drawing off the dust. Each of these cross-tunnel conveyors discharges into one com-

mon conveyor in the longitudinal tunnel, continuously carrying the dust back to the raw department of the plant, where it is mixed with the raw material going directly to the kilns.

Stokes developed a formula which means that the wind velocity necessary to support a particle will vary as the square of the radius; or inversely, the radius of the particle which the wind can support will vary as the square root of the velocity. While this formula has not been proved to be correct, it may be approximate, and this theory was applied in designing the dry dust chamber of the dust house. The temperature of the gases in the dry-dust chamber has been reduced to about 400 deg. Fahr. and the average velocity of the gases reduced to less than 1 ft. per second. This results in a very heavy dust fall in this chamber and the dust is in the best condition for returning to the kilns.

The five chambers in the wet or washing department are each 60 ft. long and 20 ft. wide. They are of steel framework, similar to that of the dry department, but the steel framework is protected by brick lining. The roof of the wet chambers is of expanded metal, with cement plaster both inside and outside.

The dry chamber, as shown, connects with each wet chamber by means of two openings through which gases are discharged. These openings are closed, when desired, by means of gates dropped down from above, so that the walls and sprays in the wet chamber may be cleaned when necessary without affecting the operation of the kilns or the balance of the house. The gates are of concrete with steel framework and other reinforcement and hang by two iron rods running up through the roof. These rods are carried by two channels, back to back. After the cleaning operation is over the openings around the two rods



Plan and Cross-Section of Plant for Collecting Kiln Dust by Means of Baffled Chambers and Water Sprays



Corroded Vertical-Post Flanges

passing up through the roof are cemented with asbestos plaster.

Each chamber consists of a series of baffles changing the direction of the current of the hot gases passing through. The gases coming out of the dry chamber pass up over the first baffle, down and through a sheet of water, under the second baffle, then through another sheet of water, over a third baffle, then up and down and onward to the

REQUIREMENTS FOR PLANT OF 3750-BARREL CAPACITY

Slurry pumps	Hp
Circulating pumps	15
Screw-conveyor for returning dust	80
5 exhauster fans at 30 hp each	25
Total	150
Labor:	
Dry department	2 men, day
Dry department	1 man, night
Wet department	2 men, day
Wet department	1 man, night
Total	270

last section, where the exhaust passes through a 1/2-in. mesh screen to the atmosphere. Sprays are located in all corners and at the top and bottom of each baffle, with the exception of the section between the dry chambers and the first sheet of water. Sprays are also located 2 ft. above the screen in the exit chamber.

The floor under the wet department slopes from the dry chamber 1 1/4 in. per foot in order to carry away the water with its load of dust. Alternate baffles are raised 6 in. above the floor, permitting the water to pass freely to the overflow.

There is a door in the end of each wet chamber, and in line with the outside door are swinging doors in each baffle. These

doors are closed except during the period of cleaning out or examination, about once a month. The exhaust from the dust house is a cloud of atomized water and steam. The temperature in the exit chamber is from 100 to 125 deg. Fahr.

The dirty water, containing about 0.1 lb. per cubic foot in suspension and an equal amount in solution, falls from the floor of the wet chambers into a set of screen-covered launders or troughs leading to the primary settling tanks. The temperature of the water as it leaves the chambers is about 117 deg.

SETTLING TANKS

The settling tanks are made of steel and are conical. The thick slurry from the eight primary settling tanks is siphoned up to troughs leading to the secondary tank, where the operation of separating the water from the dust is repeated. The clean overflow water from the primary and secondary tanks is returned to the sump for further



Destruction of Webs by Corrosion

circulation in the wet chamber. The thick slurry from the secondary settling tank is continually pumped back to the kilns, where each kiln receives its proportion of slurry mixed in with the dry material coming from the raw department. Both the slurry and water for circulating are handled by centrifugal pumps driven by electric motors.

The total amount of water required for the five 8 1/2 x 150-ft. kilns is 2700 gal. per minute, of which 350 or 400 gal. per minute are evaporated or lost. The 350 to 400 gal. are replaced by new water from the original source of supply. The temperature of the clean water which is returned to the house is about 100 deg.

The total amount of dust recovered per day is about 75 tons, 50 tons being from the dry department and 25 tons from the wet department.

The approximate horsepower required continuously for this installation, including the power required for the slurry pumps, circulating pumps and conveyors carrying the dust back to the raw department, is 120 hp, to which should be added the power required for operating the fans and handling the hot gases from the kilns.

The development of this dust settling system was compulsory, being brought about by the action taken against the California Portland Cement Company by the orange growers whose groves were near the plant. The courts have decided that the system has fully demonstrated that it gathers all the troublesome dust arising from the kilns and dryers in the manufacture of cement, and the plant is now operating at full capacity.

The system has been designed and patented by the author.

Rusting of Steel Bridges

Abstract of Paper by Clifford Older, Bridge Engineer, State Highway Department, Illinois, Presented Before Illinois Society of Engineers and Surveyors

RECENT investigations of the Illinois State Highway Department indicate that few highway steel bridges in that State are painted after their final completion and acceptance. Very serious corrosion results and is illustrated in a number of cases described in a paper presented before the Illinois Society of Engineers and Surveyors by Clifford Older, bridge engineer of the State Highway Commission.

A pony truss bridge over a railroad has wooden floorbeams seated on the outstanding flanges of the 4 x 6 x 1/2-in. lower-chord angles. These flanges were entirely destroyed and the vertical flanges were materially injured for a distance of 3 ft. over the track, allowing two of the transverse floorbeams to become entirely unsupported

and eventually to fall to the track below, after the bridge had been completed only about five years.

A serious factor in the corrosion of iron and steel is the use of salt to clear the roadway of snow and ice. This was considered at least partly responsible for the bad condition of truss members in a bridge which had been about fifteen years in service.

EFFECT OF ACID SOIL

In southern Illinois the surface soil to a depth of a few inches shows a marked acid reaction. Wherever such dirt accumulates readily, as, for instance, around the shoes, stringers, floorbeams, lower chords and other places below the bridge floor, corrosion is very rapid unless the steel is kept well protected by paint or is incased in concrete. Examination of many steel structures in this district showed that plates, angles and beam and channel webs having a thickness of 1/4 in. or less when exposed on both sides to the action of the wet earth are completely destroyed by corrosion in ten or twelve years. The initial coat of paint apparently affords protection for only two or three years.

In a bridge near Hillsboro, Montgomery County, which had been in service only ten years, a channel web originally 0.2 in. thick, and located 12 in. below the bridge floor, where a shelf angle formed a lodging place for dirt, was eaten entirely through in several places.

Examination of bridges that have been erected for some time frequently discloses the cover plates of compression members buckled between rivets and separated from the flanges to the extent of a quarter inch, the space between the plate and flange being



Corroded End-Post Web

filled with dirt and rust. This is due to the action of rust forming in the joint between the plate and flange and developing a heavy expansive force on account of its increased volume, which is approximately twice as great as that of the original metal.

EXPANSIVE FORCE OF RUST

A 234-ft. span arch bridge across the Fox River at Ottawa, La Salle County, completed in 1869, had arch ribs built up of Phoenix sections, plates and channels. A scale of rust about 3/16 in. thick had formed on each side of a web plate, between the plate and the flanges of the adjacent sections. The expansive force exerted by the formation of the scale had ruptured practically all of the rivets connecting the upper and lower halves of the ribs from one end of the bridge to the other. A length of 10 ft., partly shown in one of the pictures, had only one unbroken rivet. The blade of the knife is inserted where the shank of a rivet ought to be. In some cases the heads of the rivets were pulled off, but usually the break occurred in the shank. In a few cases the head was pulled off and the shank was broken as well. Some of the broken rivets show an apparent reduction of area adjacent to the break typical of tension failure. There were no indications that this reduction was caused by rust. In cutting out the rivets all indications pointed to a tough and ductile material.

A row of these rivets 5 ft. long was cut out and every rivet was found broken. The tenth rivet, however, was intact and when the head was cut off a sudden jar was felt accompanied by splitting noise, as the two halves of the arch rib separated appreciably for a length of 10 ft. or more.

It was found that not more than 10 per cent of the rivets connecting the upper and lower halves of the arch ribs were unbroken. It is probable that friction and crooked shanks, due to mismatched holes, had held the parts together. There was strong evidence of a recent working of these joints.

The surface steel of this bridge had been protected reasonably well with paint. Scraping disclosed a number of different colors, including red and green.

Approximate Costs of Rapid-Transit Structures

Figures Compiled by John Vipond Davies in Paper Read at National Conference on City Planning

RELATIVE costs of producing rapid-transit structures are contained in a paper entitled "Provisions for Future Rapid Transit," presented by John Vipond Davies, consulting engineer, of New York City, before the National Conference on City Planning at Toronto, May 25 to 27. Operation and maintenance, including depreciation and all other charges, will, if a road is doing a reasonably full business, use up about 45 per cent of its gross income, the remaining 55 per cent being available to pay the interest charges on the capital invested. It, therefore, can readily be seen how important it is with light traffic to keep the cost of construction and equipment low, considering that, for illustration, the Interborough rapid-transit subway in New York, consisting in part of subway and in part of elevated structure, must haul more than 2,000,000 pay passengers per annum

per mile of single track to meet fixed charges for structure and equipment; or, further, that a road which would cost, for structure alone without equipment, say \$500,000 per mile of double track, would have to haul at a 5-cent fare 910,000 pay passengers to pay interest charges on its expenditure for that structure, and, if equipment were included, would have to haul probably 1,400,000 pay passengers per annum.

The following figures are given as average costs for construction of structures and the installation of structural equipment, but without power or rolling stock. They do not include the value of property for rights of way or easement and are given on the basis of constructing a double track railroad in each case, although reduced to the cost per mile of single track:

TYPES OF STRUCTURE For Double Railway Tracks		Cost per Mile of Single Track
Trolley railroad in suburban district, either on public roads or private right of way where no paving is required, complete with overhead trolley construction, track bonded; all in operating condition		\$25,000
Trolley railroad on city streets, including asphalt or granite block pavement for width of tracks and 2 feet outside of tracks; complete with overhead trolley construction, track bonded; all in operating condition		\$42,000
Underground trolley railroad in congested streets of a city, including necessary pavements, conduits, etc., and with reasonable allowance for changes of subsurface improvements:		
New York	\$126,000	
Washington	49,500	
Elevated railroad of a type and for the loading permissible to meet requirements of Public Service Commission of New York; complete with stations, contact rail, ties and track; averages.	\$125,000	
Railroad in open cut similar to Sea Beach Railroad of Brooklyn Rapid Transit Company in Brooklyn, where work is executed with steam shovel and with concrete walls; averaging cost of bridges and stations as part of the cost; complete with contact rail, ties and track; averages.	\$225,000	
Railroad on masonry viaduct filled in with stone ballast, similar to structure now being erected on Queens Boulevard from Queensboro Bridge to Greenpoint, on Long Island, New York; complete with stations, contact rail, ties and track; averages	\$330,000	
Subway such as the Fourth Avenue Subway in Brooklyn, where work is unaffected by subsurface improvements, where the digging is easy and can be done with steam shovel and under typical, ideal conditions; complete with structural and track equipment; averages	\$402,000	
Subway such as the Broadway Subway now being constructed in New York City, where the work is very difficult and involves extreme interference with subsurface improvements of all kinds, the support of street surface, trolley car tracks, underground trolley construction, etc.; complete with structural and track equipment; averages	\$1,190,000	
Iron lined tube tunnels under waterways or below water level; complete with structural equipment and track; averages	\$2,700,000	

In connection with the above table of costs, the difference in the first cost of constructing improvements in a city like Washington, where the soil is advantageous to excavate, where the streets are broad and where there is no difficulty in changing subsurface improvements, is in marked contrast to the cost of executing similar work in a city like New York, where the material to be excavated is most difficult, where the streets are congested and where there are numerous and extensive subsurface improvements to be cared for.

FUNDS FOR HARBOR IMPROVEMENT at Oakland, Cal., have been furnished by thirty-two Government appropriations, the first of which was made in 1874, and whose total, including the 1914 budget, is \$4,061,803.

Diamond Drilling in Mexico

Driving Long Vertical, Horizontal, and Inclined Holes for Prospecting and Unwatering Hydraulic Tunnels

THE construction of 25 miles of modern tunnel for the development of the 90,000 electric horsepower hydroelectric plant of the Mexican Light & Power Company, at Necaxa, Mexico, involved about 7000 ft. of diamond-drill holes in water-bearing strata composed of large and small boulders, volcanic ash, clay, sand and gravel. These strata were very difficult to penetrate, and the completion of a troublesome tunnel in it was made possible by draining the water through drill holes. Some of the difficulties encountered and the method of operating are described in an article by J. I. Edwards and D. J. Tynan recently published in "Mine and Quarry."

One tunnel encountered a large amount of ground-water under pressure so great that sand, gravel and ash would be forced into the tunnel excavation, breaking the heavy timbers and depositing thousands of carloads of muck in the tunnel. On this account the tunnel was four times lost, and its completion appeared to be impossible until four Sullivan diamond drills were introduced to tap the veins and drain the tunnel.

HORIZONTAL DRILLING

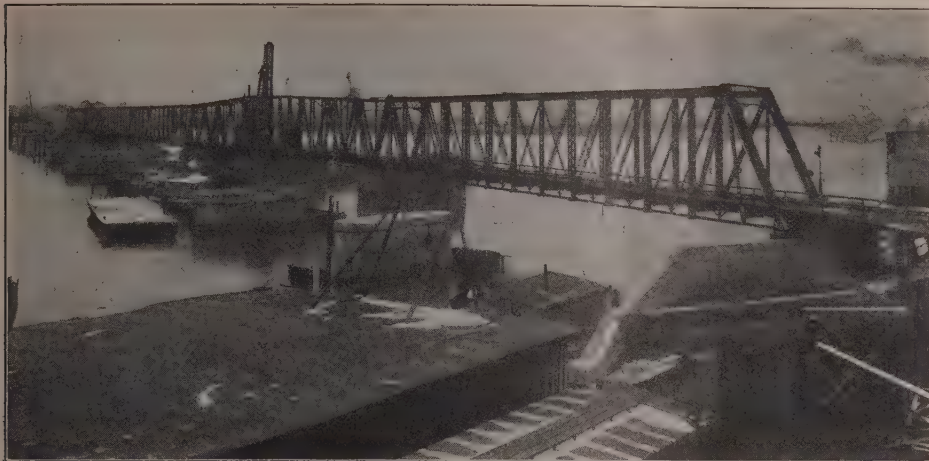
The horizontal drilling in particular was attended with many difficulties, owing to the disturbed and broken character of the ground. Holes were usually started 2½ in. in diameter. The vibration of the rods loosened large and small boulders, causing much trouble when withdrawing the bit. In many cases the rods were jammed, so that it was necessary for several men to keep the rods constantly turning with Stillson wrenches. At least four-fifths of every horizontal hole had to be redrilled ten or a dozen times, since the hole would cave in as soon as the bit was withdrawn.

Usually the 2½-in. casing was drilled in to a distance of 50 ft., from which point the hole was continued with an E casing bit, finally bringing the cuttings down to size E rods and bits, removing a 15/16-in. core. An average depth for these holes was 200 ft. Great care had to be exercised while drilling to keep the water running and the rods revolving, otherwise the caving material would bind and jam the rods as effectively as if they were cemented in.

On one occasion a body of water was met 35 ft. ahead of the tunnel face, which drained for twenty-four hours through a 2½-in. casing, and even then showed a pressure of 24 lb. per square inch. Three 2½-in. holes were drilled across the tunnel head to drain this water. One of these went to a depth of 300 ft., 200 ft. of which were drilled in fifty hours with an E bit, without once withdrawing the rods.

Prospect holes from 500 to 800 ft. deep to tunnel elevation were reached by trails which, in places scarcely 2 ft. wide, had to be made along the edges of precipices and through dense forest growths. Twelve to sixteen peons would carry an H drill along trails where the least slip meant a drop of 100 ft. A Mexican "cabo," or boss, and thirty peons were kept constantly at work, cutting trails and drill sites.

The results obtained were considered satisfactory and the cost of the work low in consideration of the conditions obtaining and the difficulties encountered.



New Piers Practically Completed and Ready for Erection of Falsework

Building New Pennsylvania Bridge Over the Maumee River at Toledo in Record Time

Part III—Tremie Method of Concreting in Deep Water; Excessive Formation of Laitance and Difficulties Overcome in Its Removal

By R. C. MILLER

Division Engineer, Pennsylvania Lines West of Pittsburgh, Toledo, Ohio

CONCRETING for the new bridge of the Pennsylvania Lines West of Pittsburgh over the Maumee River at Toledo, the foundation and formwork for which were described in the issues of May 2, page 492, and May 23, page 592, was done entirely by a tremie from a floating mixer plant. The one drawback to the method adopted proved to be the excessive formation of laitance. Owing to the depth of the water and the unsteadiness of the floating plant it was impossible to prevent this, and several methods of removing the substance were tried and rejected before a successful way was found. The experiences on this bridge suggest certain remedies for future construction.

The floating mixer plant consisted of a 1-yd. mixer, material hopper, hoisting tower with boom and discharge pipe, whirly derrick and operating engine—all set up and operated on one scow. The plant was equipped with lighting facilities so that work could be carried on at night. Cement was handled from the supply scow to the measuring room, where there was sufficient storage for one day's work. Sand and stone were handled from the supply scow to 60-yd. material hoppers by the whirly derrick operating a $\frac{3}{4}$ -yd. clamshell bucket. From the material hopper first the stone and then the sand was fed into a 1-yd. measuring bin, the cement added and the whole aggregate allowed to pass into the mixer. From the mixer the material was dumped into a $\frac{3}{4}$ -yd. bucket, hoisted in the tower and automatically dumped into the receiving hopper which carried an inclined 15-in. discharge pipe operated by a boom on the mixer scow. This brought the material directly above the point of deposit. In dry work a shorter discharge pipe was hung from the end of the inclined pipe and the whole lowered to within 2 ft. of the deposited concrete. In wet work the tremie pipe with a hopper attached to the top was handled by a separate derrick scow, as by so doing the pipe could be more easily regulated.

On account of the extreme depth of water in which the concrete was to be deposited, and the limited knowledge of the conditions

to be encountered, one pier was selected as an experiment and was run to a point 2 ft. below mean lake level. In this first pier a 14-in. tremie with a $\frac{1}{2}$ -yd. receiving hopper was used. With the operation of this pipe it was found that after the pipe was filled with concrete it would not free itself until the end of the pipe had been pulled nearly out of the concrete previously deposited, and that when the concrete did start it went with a rush. Previous to the point of starting the strain on the derrick boom was sufficient to tip the derrick boat slightly forward, so that with the quick release of the load the boat fell back to place, thus lifting the end of the pipe clear of the concrete and depositing the entire batch before the man handling the engine could catch the signal, release the friction on the engine drum and lower the pipe. This caused the depositing of part of the concrete through free water and at the same time allowed water to enter the pipe. Then, in attempting to make the pipe free itself by pouring more concrete into the hopper, the hopper filled and overflowed, causing loss of concrete, and the concrete also backed up in the incline delivery pipe. The time occupied was such that with the richness of the mixture used and the friction on the sides of the pipe the concrete hardened so that both pipes were completely plugged and from one to two hours were lost in cleaning them out with a hose. Due to the above-described conditions, the water in the cofferdam became badly discolored from the particles it was carrying in suspension, and when the water cleared a deposit of laitance 8 in. thick was found over the entire footing course.

Study developed the fact that the receiving hopper and tremie pipe were not large enough. Consequently a 20-in. pipe was made with a 1-yd. hopper. It was then found that while with the larger pipe the above-cited difficulties were not entirely overcome, they were greatly decreased, and as the work progressed the deposit was cut down by careful handling of the tremie to a maximum of 2 or 3 in.

At no time during the work was it possible entirely to eliminate the deposit, but the consequent expense and time lost in removing same was overcome in the last piece of tremie work, namely, the west abutment. A study of the formation of this deposit showed that from 9 to 12 hours were required for the full settlement of the material in suspension, and from that time on it assumed a degree of toughness according to the time it was allowed to set. Upon this fact as a basis the method of procedure in running the entire batch of tremie concrete for the west abutment was as follows:

The placing of the footing course, containing about 550 cu. yd., was started at 6 o'clock at night and finished at about 8 o'clock the next morning. Meanwhile the form for the abutment had been loaded on the derrick scow and was ready, so that with the completion of the footing course it was at once placed in the cofferdam and brought to line and grade in less than six hours. This, considering the size of the form, depth of water, etc., was remarkably fast work and undoubtedly the best of its kind during the entire construction.

INSPECTION BY DIVERS

With the form in place ready to pour concrete again in less than six hours, divers inspected the condition of the footing course and found that the sediment previously carried through the entire volume of water had settled so that it was then carried entirely in the last foot of water directly over the concrete. Very little was deposited on the concrete, but the greater bulk was still in suspension—so much so, that it was impossible to grasp or secure in any way a sample to be brought to the surface. Consequently the footing course was swept clean by a diver with a hose, thus stirring up the deposit of concrete again, so that, aside from the amount of initial set the previous concrete had acquired, the application of more concrete gave the same results as though the pouring had been continuous.

In all concrete placed by the tremie method each separate run was tied or bonded to the previous batch by scrap car axles and 8-ft. pieces of rail placed to stand equally in the two separate batches. Concrete run in the dry was bonded by means of wooden boxes.

As all piers were completed before Dec. 31, no excessively cold weather was encountered. All concrete run during low temperature, however, was protected by heating the materials before mixing. Material in place was protected, in the case of tremie concrete, by applying heat through steam pipes

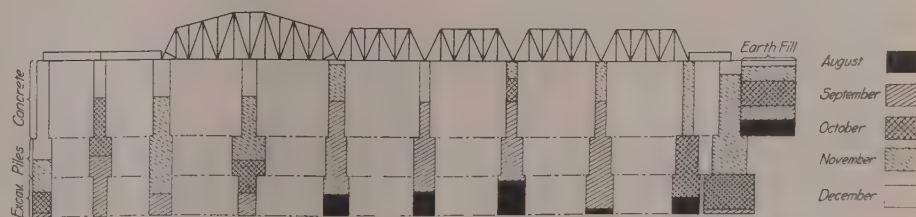


Diagram Indicating Progress Made During Each of the Five Months

to the water inside of the cofferdam around the form. In the case of neat work above the water line, large tarpaulins were thrown over the entire form, extending from the water on one side up over the form and down to the water again on the other side, and under this a line of pipe was placed with several steam jets that allowed the free passage of steam entirely around the green concrete.

LAITANCE

While laitance, or inert matter, has been experienced in large bodies of concrete deposited by the dry method, the volume has been small and the handling of it has been a matter of no difficulty in open work where it can be reached and simply shoveled off in order to clean the mass for a new batch. With the concrete placed in from 33 to 40 ft. of water, however, this laitance not only occurred in excessive quantities, varying from 2 to 8 in., but was removed with much difficulty and heavy expense, and only then after many experiments.

After the footing courses, which were about 11 ft. thick, were poured under the water it was found that this deposit on top of the footing had in part risen through the mass, but was due principally to the settlement of fine particles held in suspension in the water. The deposit varied from a milky white to a yellowish, soapy, mud-like material, similar, when dried, to chalk, very light, and in some cases containing inert sand or loam. It was different in some respects from the regular formation experienced in open work where the light particles are pushed up through the mass, or accumulate on the surface when leveling it.

Theoretically the bottom of the tremie pipe should be kept immersed in the concrete so that the batch which is deposited will pass out of the pipe and by its own head force laterally and vertically the wet concrete previously deposited, so that the load will be dropped without coming in contact with the water. This in practice, however, does not always obtain, since the pipe, being suspended from a derrick and raised and lowered by signals, cannot be regulated to such a nicety, and a small percentage of the concrete every time the pipe is moved is allowed to come in contact with and pass up through the water instead of being deposited under the concrete already placed.

CAUSE OF LAITANCE

The texture of cement and sand, including any loam, varying from an infinitesimal fineness to the allowable coarseness, together with the impurities or padding in the cement, and the free dust which, due to crushing and much handling, covers the stone, offers many fine particles which, on coming in contact with the water, become suspended in it, especially since the water is continually agitated. When the work is stopped and the water becomes quiet, the particles in suspension drop, the heavy particles of sand or impurities preceding the lighter particles of cement and stone dust, so that the deposit varies from a sandy inert mixture, immediately on top of the concrete, to the tough chalk-like formation referred to.

The deposit formed on the footings during the placing of the forms, and again at the point 2 ft. below the mean lake level, where change was made from the tremie to the dry method of placing the concrete. Between these levels its formation was prevented by the continuous pouring of the concrete.

In the work it was necessary alternately to raise and lower the tremie pipe in order to get around and over the many tension rods, and for this reason a portion of the concrete was lost, the fine particles gradually rising until the entire mass was placed, when the 2 ft. of water remaining carried so much free matter in suspension that it had the consistency of thick milk. When the water became quiet, the ultimate deposit was in many cases about 4 in. thick. Here, however, it caused little trouble, since it could be handled with shovels after the water was removed and the surface of the concrete could be cleaned with a hose.

UNSUCCESSFUL METHODS OF REMOVAL

That on the footing courses under from 21 to 29 ft. of water offered a different problem. At first the attempt was made to suck up the chalky deposit with a 6-in. centrifugal pump. While the pump would lift the very light particles, the lower portion, however, especially after setting a few days, became very plastic and tough, but not hard, so that it would not break away. In this state the best illustration to draw is that it appeared like a blanket of putty spread over the concrete.

Planks were next thrown across the forms, and long iron rods with chisel points were operated by men over the entire surface. This scheme was soon abandoned, since, while the chisel points cut through the deposit, the material was so plastic and tough that impressions only were made through it and the deposit would not break away from the rough concrete.

A clamshell bucket, both with and without teeth, was tried, but since the deposit always found the low spots in the concrete, and also because of the steel car axles which projected from the footing course to give bond to the neat work, this method was a failure.

After experimenting several days with these and other schemes, one was developed which, while slow and expensive, gave good results. A heavy iron pipe, 2 in. in diameter and about 40 ft. long, with a drawn-

out open chisel edge on one end, was suspended from a derrick boom and connected at the top with a 2-in. hose through which water under about 100 lb. pressure was delivered. This pipe was raised and lowered by the engine through the boom, the pipe dropping about 12 in., similar to a drill, and the water being forced out through the bottom, breaking away the deposit as the chisel edge cut into it. The pipe was guided by two men standing on top of the caisson, and also by a diver who took care of the cutting under the water. The small pieces which were broken away were later removed by a 6-in. centrifugal pump.

While the laitance gave more or less trouble throughout, as the work progressed we were able to decrease it by careful handling of the tremie pipe, lifting it only when absolutely necessary. By removing the deposit within a day after it had formed the labor was decreased, since a large proportion of the deposit could be pumped away.

OBSERVATIONS

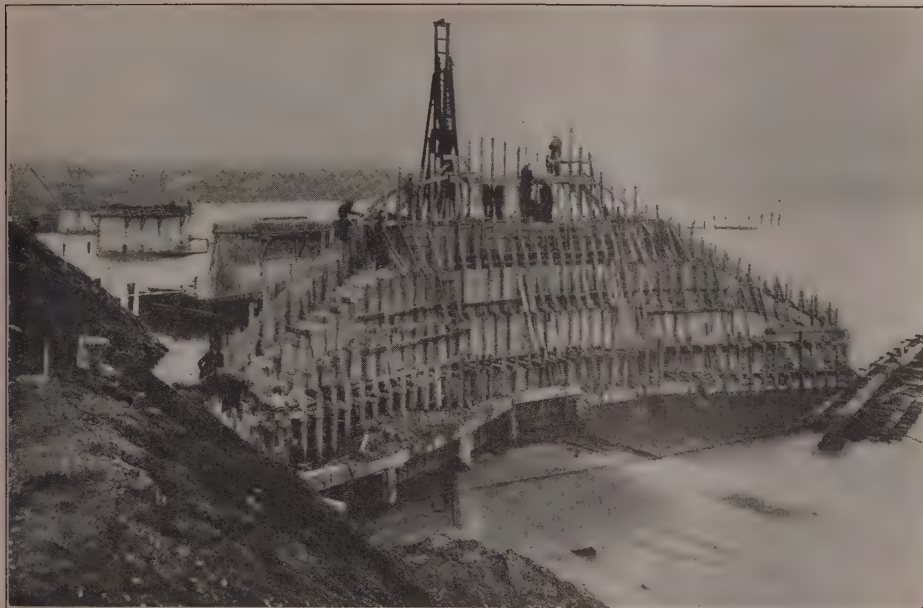
It is practically impossible to level concrete deposited by this method under water, since coaxing the surface with the pipe or leveling it in any other manner stirs up the concrete, allowing the fine particles to escape and giving an abnormal deposit.

Formation of laitance is the only important drawback to the tremie process as it is employed to-day, and to make the method a decided success some way must be developed to keep this deposit to a minimum or remove it economically. As the work progressed a pipe of larger diameter was used, the maximum being 20 in. This also decreased the deposit, since a larger batch of concrete could be handled. Hence the pipe did not clean itself so readily, and water through which the next batch would have to pass was kept out of the pipe. A still larger pipe could perhaps have been used to advantage.

Most of this trouble and delay would be avoided if all concrete under water could be run continuously, thereby bringing any



General View During Construction, with Derricks, Pump and Mixer at Work



Running Backwall of East Abutment; Pumping Hydraulic Fill Behind It

deposit that might occur to the water level. While this was done with the neat work, it is generally not practical or advisable to run the footing with the neat work, and in some cases it may not even be practical, on account of inability of the wooden forms to sustain such a great pressure, irregularity in the delivery of material, breakdowns and the like, to run the neat work continuously.

The most feasible solution would be to use several large tremie pipes, probably four or five, located between the rods in the forms, so that it would be unnecessary to move them in any direction except vertically, the pipes being filled alternately so that delivery from each pipe would reach that from the adjacent pipe. Each pipe could be raised by means of jacks when the load would not clear itself, so that the bottom of the pipe could always be maintained at an elevation just below the top of the concrete placed. The pressure from the concrete already deposited would be less than the head in the pipe, hence the pipe would practically clean itself. This would prevent any of the concrete passing through the water and prevent water from rising in the pipe, so that the only laitance formed would be that released from the surface of the concrete as it is lifted up and comes in contact with the water. Even this method would be expensive and would require extreme care to keep from blocking the pipes with hardened concrete.

PLANT

During the construction of the Toledo bridge the contractors, with almost unlimited equipment at their command, concentrated the best of their forces on this work. The plant used consisted of three floating pile drivers, one of which was also equipped for pulling piles; also two roller pile drivers, two single-boom derrick scows, either of which could be quickly fitted up with orange-peel or clamshell buckets for dredge work; one long double-end derrick scow carrying two booms, used mostly for handling and transferring material and forms, and one concrete mixer plant complete with tender boat and scows. All of the above-mentioned plant with two tugs and four ordinary deck scows were kept on the work continuously. In addition, one dipper dredge with tender and scows and

two hydraulic dredges, one with a 24-in. and the other with a 15-in. discharge pipe, were used as required.

The substructure, which was started Aug. 1, 1913, and completed Dec. 29, was built under contract by the Great Lakes Dredge & Dock Company, of Cleveland, under the direction of R. Trimble, chief engineer maintenance of way of the Northwest system, Pennsylvania Lines West of Pittsburgh; J. C. Bland, engineer of bridges; the writer, division engineer, and H. T. Pettegrew, engineer in charge.

Erecting 430-Foot Steel Mast without Derricks or Falsework

Wireless Telegraph Pole of Sectional Hollow-Steel Construction with Telescopic Wooden Pole at Top

A HOLLOW-STEEL mast 42 in. in diameter at the base and surmounted by a wooden topmast extending it to a total height of 430 ft. was rapidly erected by tackles suspended from the topmast which worked telescopically in the upper section of the steel cylinders and was hoisted up as the latter progressed section by section. In this manner the structure was made self-supporting and was erected with a plant comprising only the hoisting apparatus, the working platform and hand tools.

The J. G. White Engineering Corporation, of New York City, has recently completed the erection for the Marconi Wireless Telegraph Company of America of thirteen tall steel composite cylinder type masts at New Brunswick, N. J. Each mast has a hollow cylindrical portion 42 in. in diameter, made up of quarter sections up to a height of 195 ft. and 30 in. in diameter, made up of half sections up to a height of 400 ft.; above that height it consists of a single pine timber 42 ft. long over all and 12 in. square for a distance of 31½ ft. from the lower end, above which it has a circular cross-section decreasing in diameter from 12 to 6 in.

DETAILS OF CONSTRUCTION

The lower part of the steel portion is composed of quarter-cylinders 15 ft. long and 42 in. in diameter inside, bolted together

through vertical and horizontal flanges. The upper part is made up of semi-cylindrical sections 10 ft. long. The mast is seated on horizontal 7 x 7-ft. steel foundation plates connected by eight 2-in. vertical bolts, 78 in. long, and buried in a 12-ft. cube of concrete made of 1 part Portland cement and 6 parts aggregate.

The mast is secured by four sets of guys, each set consisting of eight 3-in. flexible galvanized crucible steel wire ropes shackled to the mast and to a U-bolt engaging a steel anchor plate buried in a 12-ft. concrete cube. The guy ropes are provided with oval stress insulators placed about 100 ft. apart to prevent them from acting as aerial receivers, and with turnbuckles at the lower end to take up the stretch.

ERECTION OF LOWER SECTIONS

The top of the topmast was fitted with bands, cap and derrick irons, to which were attached four cage-hoisting tackles, two material hoisting lines, and four temporary guys. Temporary horizontal spreaders were provided to offset the tackles. The topmast was erected by shear legs seated on the upper foundation plates and when it had been secured in position by its guys attached to the permanent anchorages the shear legs were removed. The four quarter cylinders of the first section of the mast were then hoisted by the tackles attached to the topmast and permanently bolted together at the foot and to the base plate.

The erection cage, about 10 ft. square and inclosed by a railing 3 ft. high, was made in two halves and bolted together, inclosing



Steel Mast 430 Feet High

the steel pipe. One of the cage-hoisting tackles was attached to each side of the cage, the men entered the cage and the cage was hoisted to permit the completion of the bolting of the longitudinal flanges of the first sections of the mast. After this was done the mast heel hoisting rope was brought down inside the cage and the material hoisting ropes brought down outside the cage, and all of them led back to the hoisting engine. Horizontal diaphragm plates were placed on top of the first section of the mast and the next quarter cylindrical sections hoisted up, seated on it and bolted through it to the top flanges of the lower section. Then the vertical flanges of the second sections were bolted together, and the cage was hoisted up to follow as the bolts were secured.

COMPLETION OF WORK

After the two lower sections of the mast had been erected the temporary guys on the topmast were loosened and the topmast and its suspended cage hoisted about 30 ft. to a position where the topmast was secured by the insertion of a fid through it to rest on the upper diaphragm plate. The topmast was lowered to rest on the fid and the temporary guys were readjusted. Four more mast sections were hoisted up separately, erected and bolted together, the mast and cage raised again, and the operation repeated. Permanent guy ropes were brought up between the cage and the mast and connected to the latter through the vertical flange bolts. After the mast was erected the cage, tackle and other temporary apparatus were removed by a man seated in a boatswain's chair, and the work was completed.

Each mast was erected by a gang of four men in the cage, two ground men for sending up material, four ground men working on the guys, one foreman and one hoisting engineer. The hoisting was effected by a Lidgerwood double-drum, two-spool hoisting engine, and the best record made was the completion of one mast in eight eight-hour days. Three picked crews of erectors were simultaneously at work on different masts and developed a strong rivalry to make the best record. One crew commenced the erection of a mast one section behind the other crews and finished in advance, thereby winning the prize of a turkey dinner, which was consumed in the cage at the top of the mast.

THE EFFECT OF FOREST FIRES on stream flow is claimed to have made itself felt at Wallace, Idaho, since 1910, when the watershed which furnishes the city's water supply was burned over. A bulletin of the U. S. Forest Service states that the basin had an area of about 2000 acres, formerly well timbered with trees from 50 to 200 years old, and that these were almost wholly destroyed in the year mentioned. Before the fire the stream flow was never below 1000 miner's inches. Since then it has fallen to 250 miner's inches and the company furnishing the water, light and power has been compelled to spend considerable sums of money annually in developing power from steam and using part of it in pumping water. Records of the weather bureau at Wallace show that the precipitation has been about normal. Hence the townspeople think the unevenness of flow must be due to the destruction of the timber and not to any change in climate or rainfall.



Baseball Grandstand, Bleachers and High Brick Wall

Brooklyn Baseball Grandstand

Design of \$275,000 Reinforced-Concrete and Steel Structure with 20,000 Seats, Built Complete in Thirty-One Days by About 1000 Men

THE baseball grandstand of the new Federal League at Washington Park, Brooklyn, is a reinforced-concrete structure with a structural-steel roof. It has a seating capacity of 20,000. It was built simultaneously with a structure in Chicago that was exactly similar except that structural steel was substituted at Chicago for the reinforced concrete to expedite the construction, which, however, was no more rapid than in this case, where the work was done by about 1000 men in thirty-one days.

The seating platform, 119 ft. wide, is of a rounded V shape in plan, 862½ ft. long from end to end around the outer edge, and is symmetrical about the center line, except that one leg is about 43 ft. longer than the other. Except for the ramps, platforms and rooms located under the seating floor, the cross-section is uniform throughout, like the typical section shown, and the elevations of the transverse bents are duplicates. The columns are braced by longitudinal struts and by special concrete beams and girders for the intermediate floors. The inclined girders have varying depths, but are all 12 in. wide and are cast integral with the columns.

The floor slabs are monolithic except for full-length transverse expansion joints about 54 ft. apart, every fourth or fifth panel. The joints have steel curbs and are filled with asphalt. The floorbeams and columns at these points are made double, but are set close together and separated by a very thin joint formed by the insertion of diaphragms in the forms. The lower surface of the floor slab is inclined and the upper surface is offset to form the 8-in. risers and 33-in. horizontal treads. Both top and bottom surfaces are reinforced.

All columns have rectangular cross-sections with chamfered corners and are reinforced by vertical bars without hooping. They have separate footings 6 ft. deep proportioned for a foundation load of 1¼ tons per square foot. Twenty-one of them, 16 ft. square, are special and are reinforced with double tiers of bars. The remainder, 8 ft. square, are not reinforced. The columns and footings are proportioned for the future addition of a second-story tier of seats and the upper ends of the columns have pockets formed in them in which cast-iron pedestals were set to receive the field-spliced structural-steel roof columns. This provided a connection above floor level which permitted the steel roof and columns to be raised at any future time to allow for the construction of the second tier of concrete columns. It also allowed the cast-iron pedestals to be grouted in and the structural-steel work to be erected later without interfering with the concreting.

All of the adjacent buildings, including some heavy factories and power plants, have pile foundations, and it was at first intended to load the footings 2½ tons per square foot as provided for by the drawings which had been prepared for the duplicate structure in Chicago. To demonstrate the capacity of these footings, trial tests were made under the direction of the Department of Buildings of the Borough of Brooklyn, and in accordance with the results obtained after the commencement of the work the footings were symmetrically extended to double their original areas.

The floorbeams and girders and some of the struts are integral with the columns,

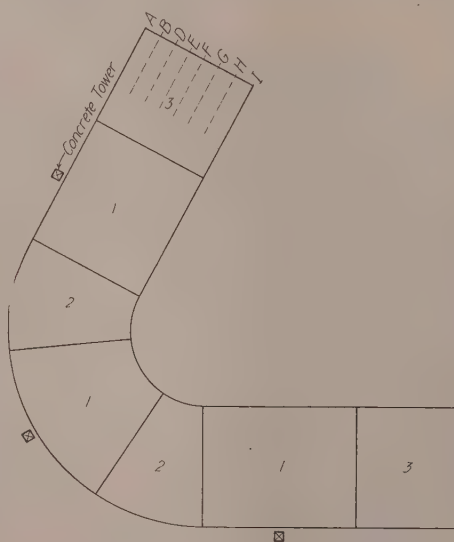


Diagram of Construction Section

but in cases where the horizontal members serve as compression struts only, about 30 per cent of them were concreted later and were bonded to the columns by reinforcement bars projecting from the latter.

The inclined floor slabs were made without top forms, and previous to construction anxiety was entertained lest the pressure head of the concrete should force it out under the open lower edges of the riser boards and cause it to overflow in the horizontal surfaces of the treads. It was demonstrated, however, that the flow of the concrete was obstructed by the reinforcement bars and could be satisfactorily controlled by varying the stiffness of the mixture, so that no trouble was experienced from this source. The horizontal wearing surfaces of the floor slabs were finished by troweling with "Master Builder" hardening until the concrete was 'set, an operation which required variable time, dependent on the temperature, which ranged between 24

State Inspection of Dams in Connecticut

Legislature Has Passed an Amendment to Old Law So That a Board Could Be Organized, Rules Formulated and Records Kept

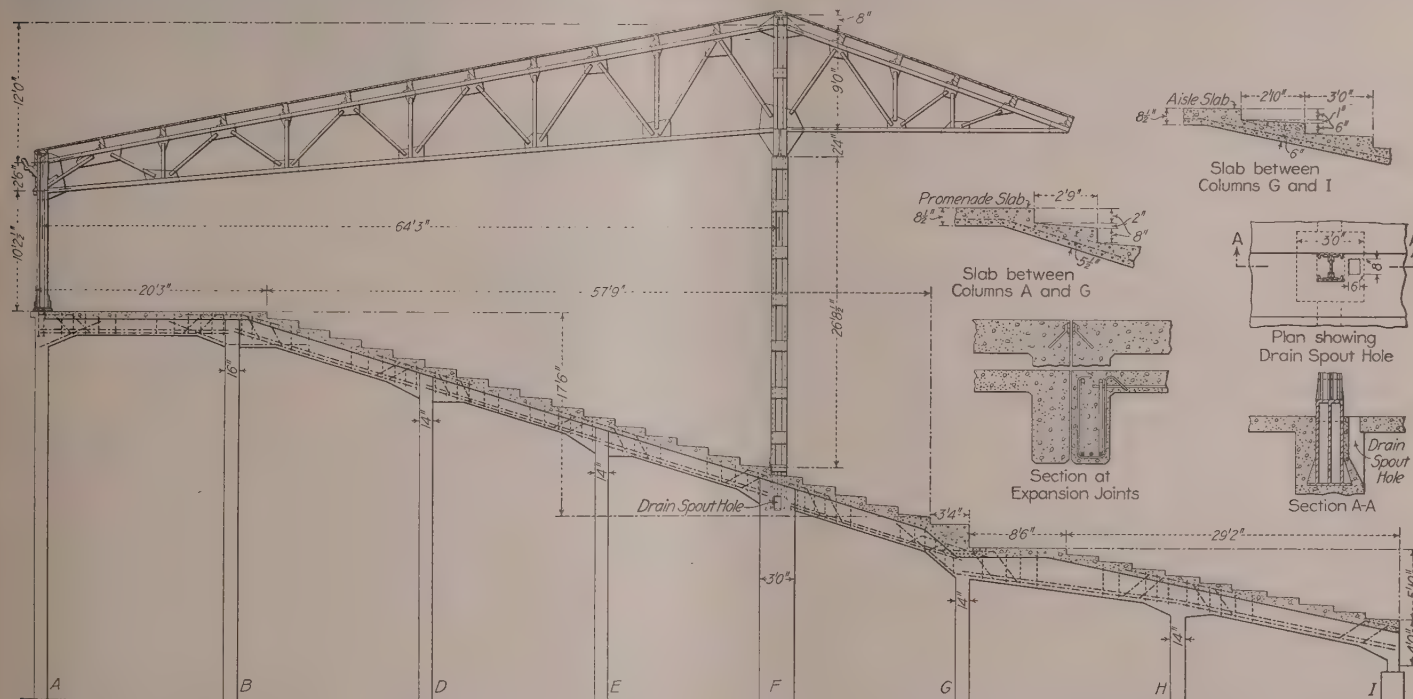
STATE inspection of dams and reservoirs has for many years been provided for by law in the State of Connecticut, but not until the last legislature was this law amended so that a board could be organized, rules formulated and official records kept. The old law merely stated that the dam owner must have the work approved by some member of the board and that the dam owner had to pay the expenses for such inspection. The new law approved June 7, 1913, reads as follows:

The commissioner of rivers, harbors, and bridges, who is a civil engineer, and one civil engineer residing in each congressional district to be appointed by him shall con-

to withstand the action of water under any circumstances which may reasonably be expected to occur, he shall at once serve notice on the person or corporation owning or having the care and control of the same to place said dam or reservoir in a safe condition under the supervision of said engineer.

When such repairs are completed to the acceptance of said engineer he shall issue a certificate of such acceptance to said person or corporation who shall record the same in the land records of the town in which said dam or reservoir is located. If said engineer shall find the dam or reservoir to be secure and safe the expense of such inspection shall be paid by the applicants.

Before any person or corporation shall construct a dam or reservoir or alter, add to, or replace any dam in a locality where life or property may be endangered through the insufficiency thereof, the



General Cross-Section of Grandstand and Floor and Column Seat Details

and 58 deg. while the work was in progress.

The last concrete was poured April 18, the installation of drains and erection of the steel roof were started, and the pavilion and offices finished and fitted, ground graded, rolled and sodded, the 20-ft. brick inclosing wall finished and coped, and all of the work except a small percentage of the roof construction was completed on May 2.

The structure was designed by Zachary T. Davis and Charles B. Davis, architects, of Chicago; C. B. Comstock, of New York, associate architect, and E. C. & R. M. Shankland, of Chicago, and R. Baffery, of New York, engineers. The contract was executed by the P. J. Carlin Construction Company, of New York, of which J. P. Carlin is president; Fred Carlin, superintendent, and J. Stevenson, superintendent of reinforced-concrete construction.

USING DERBIES AS BUMPERS.—A New York contractor always wears a derby in tunnel work, because it acts as a bumper and protects his head in crowded quarters.

stitute a board of civil engineers, who shall have supervision of all dams and reservoirs in any locality, where, by the breaking away of same, life and property may be in danger.

The members of said board shall be sworn to faithfully and impartially perform the duties imposed upon them by this act and shall continue in office for the term of two years and until others are appointed in their stead. They shall meet and organize, appoint a chairman and secretary, formulate rules, and keep records of all official acts. The members of said board shall each receive an annual salary of \$100 and their necessary and reasonable expenses, which are not chargeable elsewhere as hereinafter provided. The members of said board shall each receive \$10 per day and their necessary and reasonable expenses while actually employed.

Upon the application in writing of two or more persons or corporations who would suffer loss or damage by the breaking away of any dam or reservoir, a member of the board of civil engineers shall forthwith inspect the same and if in his opinion said dam or reservoir is not sufficiently strong

plans, specifications, and necessary data for such dam or reservoir shall be submitted to a member of said board of civil engineers who shall examine the ground where the dam or reservoir is to be built and the plans and specifications therefor. If he approves the same he shall issue a certificate authorizing the construction of such dam or reservoir, or such alterations, additions, or replacements. No such dam or reservoir shall be constructed nor such alterations, additions, or replacements made without such approval and certificate. If said state engineer deems it necessary he may, before issuing said certificate, call in for consultation and advice the state board of civil engineers or any member of said board.

The engineer under whose authority a dam or reservoir is being constructed or a dam is being altered, added to, repaired, or replaced shall inspect or cause the work to be inspected to the extent necessary in his judgment to determine whether the structure will be safe and secure, and when the work has been completed to his satisfaction he shall issue a certificate approving the same, which certificate shall be recorded

in the land records of the town in which such dam or reservoir is located.

Any person aggrieved by any decision of a member of said board of civil engineers shall be given a hearing by said board. Any decision of said board may be appealed from to any judge of the superior court within twenty days of the date of such decision.

Every person or corporation who shall build or repair any dam or reservoir except in compliance with the provisions of this act, or shall use any dam or reservoir when constructed or repaired without obtaining the certificate provided for in this act, shall forfeit five hundred dollars for the use of the state. Any person or corporation constructing or repairing a dam or reservoir, or using any such dam or reservoir when constructed or repaired without complying with the provisions of this act may be enjoined from constructing or using such dam or reservoir.

The state's attorney of the county in which such dam or reservoir is located, upon the complaint of any engineer designated under the provisions of this act, shall institute an action to recover such forfeiture and to enjoin the construction and use of such dam or reservoir.

Demolition of Tower Building, New York

Type of Construction and State of Steel Preservation After Twenty-five Years' Service

AMONG the first of the tall office buildings in New York was the Tower Building, which although only ten stories high was considered a skyscraper when completed in 1889. Its recent demolition has called attention to its position among pioneer constructions of the modern type office building and it has been mistakenly credited as the first example of steel cage construction. It illustrates an early stage in the development of tall steel buildings, the different character of details prevailing only twenty-five years ago, and affords valuable information on the effects of corrosion on iron and steel members imper-

fectly protected through a quarter century of service.

The following official data regarding these points have been derived from an inspection directed by Rudolph P. Miller, superintendent of buildings, New York City, and reported under date of Feb. 5. The building, about 159½ ft. deep and from 21½ to 39½ ft. wide, had cast-iron columns 20 in. square and 1½ in. thick in the basement, which were fireproofed with an outer shell of cast iron ¾ in. thick. The floorbeams and girders were wrought-iron I-beams with bolted field connections, and although the outer walls of the lower five stories were supported on wall beams at each floor, the floorbeams in the upper five stories were wall bearing, thus making the building conform only partly to the cage type of construction.

The flat side-bearing terra-cotta floor arches were sprung between the webs of floorbeams 4½ ft. apart and did not incase their lower flanges. The foundations were double rows of wooden piles driven to hardpan and having their upper ends incased in



Exterior Column and Shell

Column and protecting shell both slightly rusted.

The outer shell of a fourth-story exterior wall column was slightly covered with rust, and rust spots were beginning to form on the interior column; but a number of similar columns were examined and found to be almost entirely free from rust.

One of the worst cases of corrosion found was at the windbrace connection of a basement column, where rust had formed around the bolt holes as well as over the entire contact surface of the connection angles, which, however, were not sufficiently injured to reduce their strength to any material extent.

A header I-beam was mostly free from rust except at the connection. An entrance corridor floorbeam exposed to moisture was almost completely covered with rust, except where mortar adhered to it, but its surface was not badly pitted.

An accurately faced column base in the front of the building, although exposed to the weather, was practically without rust, and was thought to have had a very tight connection to its pedestal.

Considerable of the steelwork in the wall of the adjacent building was exposed by the removal of the Tower Building, and where the water had probably percolated between the two walls some of the steel columns and girders were badly rusted and a rust scale 1/16 in. thick had formed on the under side of a column plate.

Almost the entire exposed surface, including rivet heads, of a wall column was covered with rust except the part marked "paint," which was covered with a heavy coating of graphite.

No unusual or surprising features were disclosed by the report, which included conclusions in accordance with general belief, such as the ready formation of rust between contact surfaces, extra probability of corrosion near the ends of beams resting on brick or stone work, and of improperly cleaned iron under the paint, and the excellent protection afforded by cement mortar in close contact with the metal.

As linseed-oil paint in contact with cement becomes dry and incohesive it is considered immaterial whether steel thoroughly incased in cement mortar or concrete is painted or not.



Column in Adjacent Building

Exposed surface and rivet heads covered with rust.

the concrete footings of the cast-iron column bases. In the absence of definite information, appearances indicate that the iron was cleaned and protected with at least one coat of metallic, linseed-oil paint, or with red lead and linseed oil. Bradford L. Gilbert was the architect.

CONDITION OF IRON WORK

A careful and thorough examination made as the building was demolished showed "practically no case of very bad rusting, that is, of corrosion sufficient to impair the strength of the metal." The condition of a number of typical members is illustrated by photographs, some of which are here reproduced but fail to give satisfactory evidence of the corrosion on account of the lack of color, irregularity of surface and difficulty of distinguishing in the engravings between paint, cement, dirt and corrosion. In several instances the sharp outlines and solid appearance of the metal indicate that it is substantially sound and unchanged.



Connection of Struts to Basement Columns
Badly rusted around bolts; worst case in building.



Typical Grading in Fraser River Canyon



Fraser River Canyon—C. P. R. on Left and C. N. P. R. on Right

Building the Canadian Northern Pacific through British Columbia

Low Railroad Grades over the Rockies Secured by Comparatively Easy and Cheap Construction in a Rugged, Mountainous Region

GROUND was first broken in British Columbia for the Canadian Northern Pacific Railroad June 10, 1910, and since that date construction has been carried on continuously at a very rapid pace, considering the nature of the country traversed and the difficulties encountered. It is now expected that by late summer or early fall of the present season the last spike will be driven and through trains will operate over the newly completed transcontinental line.

Engineering interest in the difficult work of building the line through British Columbia has been enhanced by the high construction standard which was adhered to through sections where the cost has been very great. An insight into the plan laid down for construction on the Canadian Northern Pacific line is given by the fact that when the first 114-mile stretch of the track was laid inland from Vancouver a passenger train traversed the newly completed section at a sustained speed of 55 miles per hour without danger or discomfort to the passengers. This was even before that portion of the line was turned over to the company by the contractors.

Along this part of the route adjacent to the Pacific terminus there is an exceptionally direct alignment and many long tangents, some of those between New Westminster and Chilliwack being 6 or 7 miles in length. Of course, inland, in the narrower valleys and canyons of the three mountain ranges traversed, equally long tangents are not to be expected, but the same construction standard is maintained, and the ruling westbound grade in British Columbia is 0.4 per cent compensated for curvature, while the ruling eastbound grade is 0.7 per cent over the summit division, 0.35 per cent from Boston Bar to Kamloops and 0.4 over the other divisions. The curvature nowhere exceeds 8 deg. In running from Yellowhead Pass to Port Mann there will be only 22.3 miles of adverse grades—that is, about 96 per cent of the way is either level or downhill to westbound traffic.

The outstanding feature of the construction has been, primarily, the heavy grading, but a great many conditions limited the work, and the transportation difficulties that confronted the contractors were not the least of these. The erection of steel bridges and viaducts—of which there are 20 in the province—could not be carried out until track had been laid to the crossing. Prior to the beginning of construction, however, perhaps the most difficult and hazardous part of the entire project was the work of making the location surveys. The route of the new line follows the Fraser and Thompson Rivers, and the engineers were working continually on steep slopes or precipitous canyon walls. A large part of the canyon surveys were made in the winter, although engineers were constantly in the field from May, 1909, to May, 1913. During the winters of 1909 and 1911 there were at times as many as 160 to 180 men on the survey force. Part of the location in the Fraser and Thompson Rivers canyons was made when the ground was frozen, and the ice on the steep and rugged slopes added greatly to the danger and difficulty of the work. On parts of the line the engineers

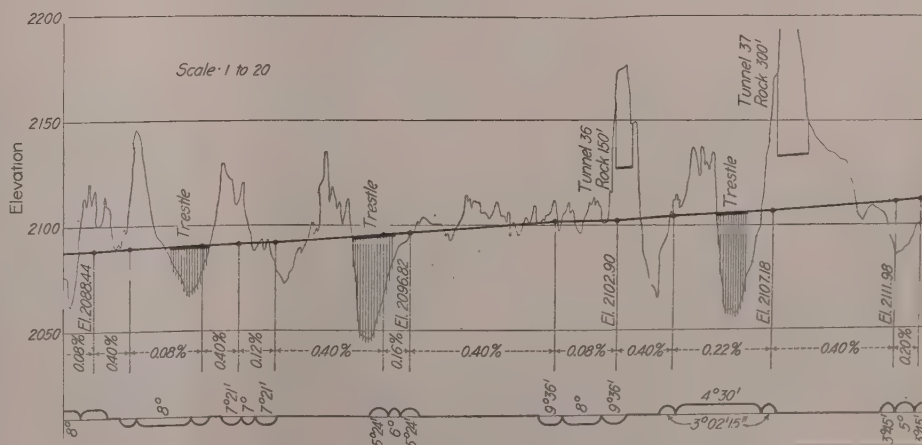
were 100 miles from the nearest settlement, and pack horses were depended on for supplies. During winter months the pack train could not work and a full month elapsed between visits of the mail carrier.

Practically the same condition had to be met by the contractors, who took in such equipment and materials as they could on horseback until the tote-roads were constructed. In some instances boats or barges could be used, and on the North Thompson River the contractors built a stanch stern-wheel steamer specially for use in the work of grading this section of the line. However, much of the grading in the interior was done by hand methods because of the difficulty of getting in equipment.

GRADING

The grading which was required in such rugged country as that traversed in British Columbia in order to keep the ruling grades down is one of the reasons for the high cost on this part of the transcontinental line. The average cost of the entire 500 miles in the province is estimated to total about \$70,000 per mile. The coast division did not involve expensive work, the average cost being \$50,000 per mile from Port Mann to Yale and \$140,000 per mile from Yale to Lytton. In one instance the grading cost for a single mile, exclusive of track, fence or telegraph, amounted to \$326,300. This represents a yardage moved of more than 250,000 cu. yd. and 548 ft. of tunnel.

At other points on the line the difficulty



Portion of the Canadian Northern Pacific Railroad Profile

of securing a cut which would not slide delayed the work and increased the cost. An instance of this is the case of the Thompson slide, shown in an accompanying illustration, which is only 500 ft. long where the line crosses it, but from which about 100,000 cu. yd. of material had to be removed before a satisfactory slope was secured. From the largest slide encountered about 350,000 cu. yd. of material have already been removed, and the slide is still moving. Typical of the precipitous slopes in the canyons is the location at the west end of Sumas Mountain, where the tunnel portal is in the face of a sheer bluff at whose foot the water stands 60 ft. deep where the fill begins.

Natural conditions were not always against the builders, however, and well toward the center of the mountain division a stretch of the line was found where a level bench of rock only slightly above or below grade extended for $2\frac{1}{2}$ miles beneath a deposit of loose earth and gravel. This afforded an excellent opportunity for hydraulic sluicing, which inexpensive method was successfully used for handling a large amount of material. Water was readily obtained from the nearby creeks, so that the supply never had to be brought more than half a mile. Twelve and 14 in. wood-stave pipes were used, and delivery was made to $2\frac{1}{2}$ or 4-in. nozzles, as desired, at a pressure of 120 lb. per square inch.

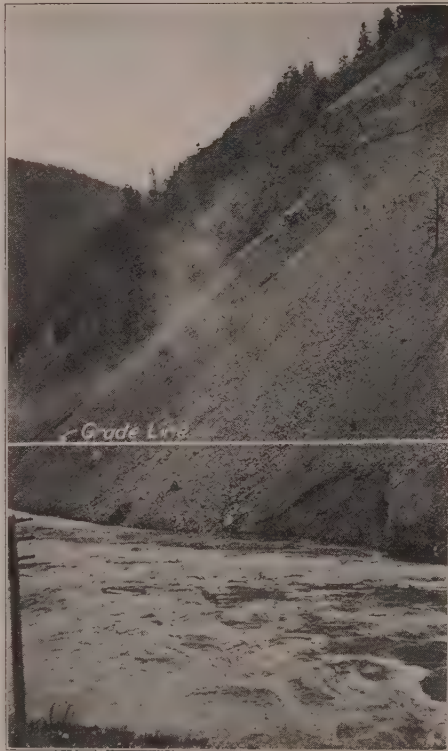
For a distance of about 15 miles near Yellowhead Pass the Grand Trunk Pacific Railway follows along the sidehill just below the Canadian Northern, and the slope and proximity of the two lines in places precluded the usual method of spoil disposal. To avoid overhauling on the Canadian Northern grading work, a series of "mucking chutes" were built, which made it possible to dump the spoil beyond the right-of-way of the road below. Six chutes, each 30 ft. wide and supported on trestles, were built about 1000 ft. apart, and for $1\frac{1}{2}$ miles all material taken from the grade was wheeled in barrows and dumped from the ends of these chutes.

TUNNELS

Comparatively little difficulty has been met with in the construction of Canadian Northern tunnels, perhaps on account of their short average length. There are forty-four tunnels between Port Mann and Yellowhead Pass, but the total length is



Difficult Point in Location



Line Crossing Thompson Slide

only 23,704 ft. Most of these tunnels are through rock, but it has been found advisable to line most of them with timber.

At mile 134.38, where a 249-ft. tunnel was completed late in 1912, a large slide started about six weeks after the tunnel was finished, and so badly shattered the roof that in removing the slide the work was finished as an open cut instead of a tunnel. This was not final, however, as a second slide occurred some time later, which swept the sidehill clean. At present there is a bench cut where the tunnel first stood, and the swift current of the Fraser has carried away the material which slid out, so that there is no indication that the grade here ever differed from the adjacent work.

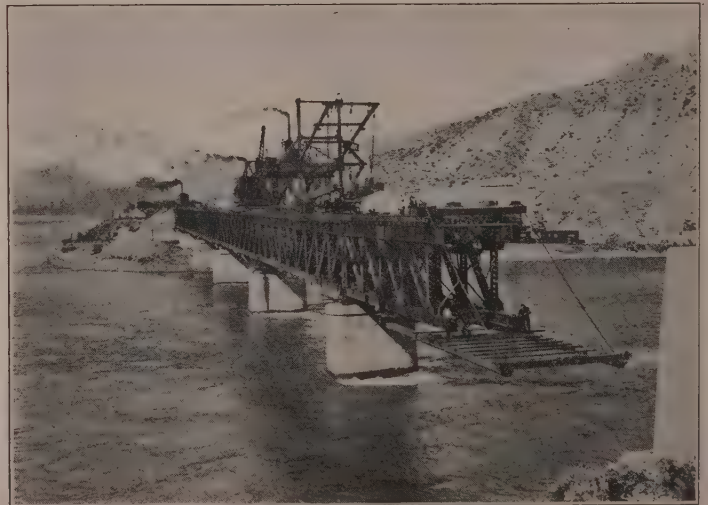
The method of supervising construction throughout the line in British Columbia was to locate division engineers in charge of "divisions," whose length ranged from 30 miles in difficult work to 60 miles in the lighter construction. On each division were from four to six resident engineers in charge of sections from 4 to 10 miles long. The division engineers reported at Vancouver direct to T. H. White, chief engineer of the Canadian Northern Pacific Railroad. Between Port Mann and Yellowhead Pass there were fifteen divisions in all. The principal contractors were: Port Mann to Hope, Northern Construction Company; Hope to Kamloops, Northern Construction Company and Welch; Kamloops to Yellowhead Pass, Northern Construction Company and Cowan Construction Company. A total of about 10,000 men were in the employ of the contractors during the height of the work. The steel bridges were designed by Waddell & Harrington, who also supervised their construction.

Europe's Highest Dam Completed

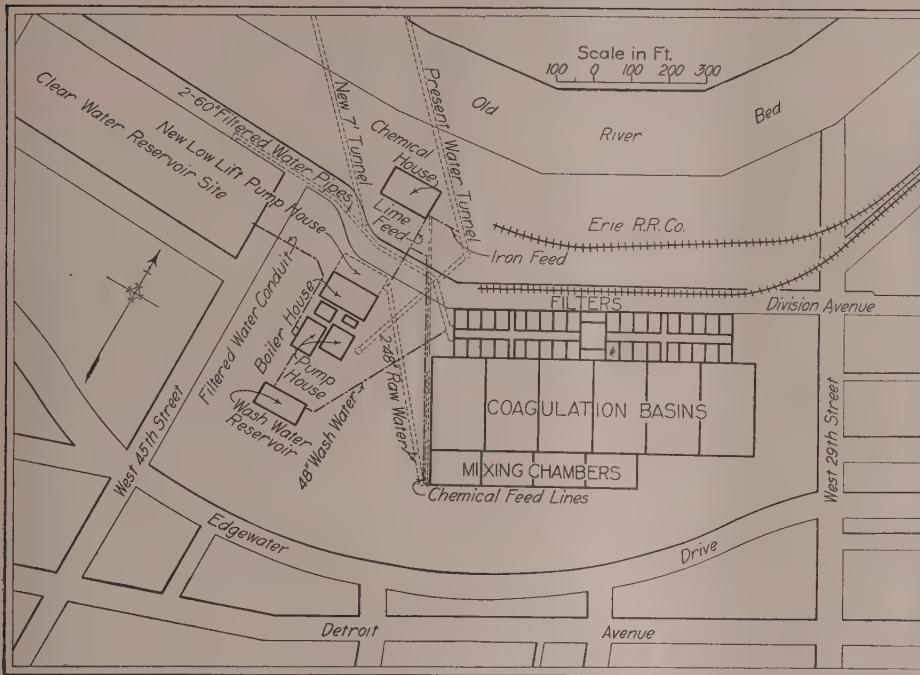
WHAT is said to be the highest dam in Europe has just been completed across the River Bober, near Hirschberg. It is 204 ft. high, 164 ft. wide at the base, and 24 ft. at the top, with a curved plan, concave to downstream, of a radius of 820 ft. It contains about 9,000,000 cu. ft. of stone masonry and cement. There are a spillway 280 ft. wide and two outfalls at the base 4 ft. 11 in. in diameter. The dam was erected for the double object of flood prevention and power. The power house is provided with four turbine-driven generating sets, each developing 1500 hp as a minimum. The cost was \$1,418,270.



Bridge No. 7, Three Miles above Ashcroft



Bridge No. 4, Ten Miles below Ashcroft



Arrangement of the Several Parts of the Cleveland Filtration Plant

Water Purification at Cleveland

Two Plants with Combined Capacity of 225,000,000 Gallons Daily, Making Largest Mechanical-Filter System in Existence

ONE of the largest mechanical-filtration systems in this or any other country has been started at Cleveland, Ohio, to treat Lake Erie water not only for the removal of turbidity and bacteria but also to decrease the hardness. The first plant, located at the West Side pumping station, will have a capacity of 150,000,000 gal. daily, and the second, at the East Side, near the end of the present 9-ft. tunnel, will have a capacity half as great as the first. Work on the excavation for the larger unit has been under way since Jan. 27, and on May 1 the John F. Casey Company was awarded Contract 1 at \$869,059 for the mixing chambers, coagulation basin, filter foundation, filter units and main piping, the detail plans for this contract having been prepared in record time between Jan. 1 and April 1. Other contracts will follow as soon as plans are completed for coagulant house, filter superstructure, filter equipment and clear-water basin.

Last July the filtration commission, consisting of Prof. W. A. Smith, president; R. Winthrop Pratt, consulting engineer, secretary; Dr. William T. Miller, Prof. Hippolyte Gruener and Dr. R. G. Perkins, recommended filters of the mechanical type and established a 100,000-gal. daily test filter, where lime and iron treatment and softening studies have demonstrated that the water is comparatively easy to treat. These studies are still in progress and include a proposition to burn the lime sludge.

Excavation of 40,000 cu. yd. from the site at the West Side plant, which is just under the 90-ft. bluff to the east of the pumping station, was carried out by the city with a new Marion 1½-yd. steam shovel. The earth was carried away twenty-four hours per day through the streets by the street railway company to a fill in the eastern part of the city. This work cost less than 40 cents per yard. The fill having been completed, a contract was let to the Fred R. Jones Company to excavate the remaining

300,000 yd. in the plant and clear-water reservoir, haul it 7000 ft. in a westerly direction and dump it into the lake for fill for park purposes. The contractor rented the shovel from the city. Rush methods will characterize the work, as it is planned to have filtered water by the fall of 1915.

Foundation problems necessitated spreading out the structures and limiting the load to 3000 lb. per square foot. The material consists of an old cinder fill underlaid with pockets of quicksand, peat and clay. The location near the pumping station was chosen so as to obtain water from the new West Side tunnel, now under construction. Furthermore, the necessary land was here available. The long axes of the various structures are parallel with the lakefront.

Water from the reconstructed pumping station will be lifted by low-service pumps to four mixing chambers located just under the bluff, thence it will pass in general

toward the lake through the six coagulation basins to the filters. A large clear-water conduit, provided under the filter units, leads to a covered clear-water basin to be located on a site to the west of the pumping station.

MIXING AND COAGULATING BASINS

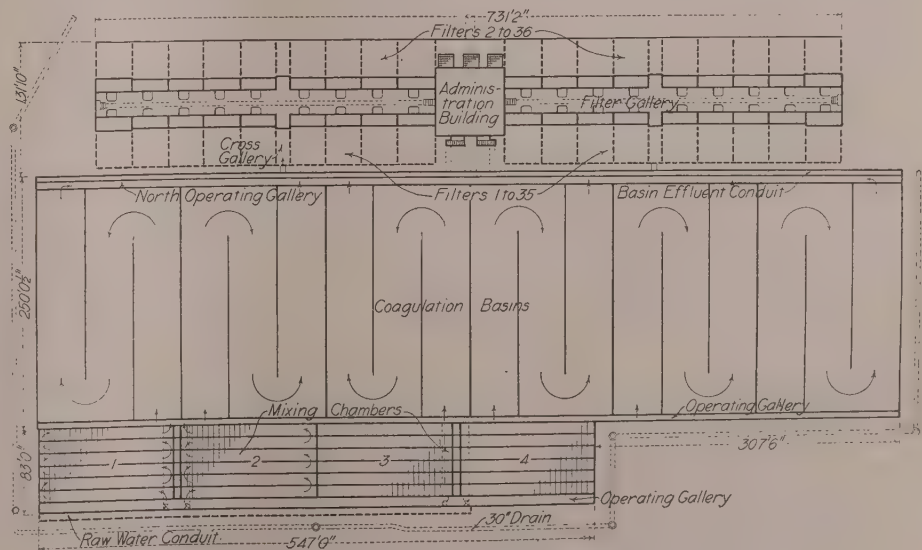
One-half hour is the time normally provided in the four mixing chambers through which the water may travel at the rate of 1 ft. per second, as now planned; by various combinations eight different velocities may be obtained. Each compartment has five vertical round-the-end concrete baffles, 11 ft. apart, with wooden up-and-down baffles, 5 ft. 3 in. apart. The bottom and top of the wooden baffles are adjustable. Floor slopes of 1 to 5 lead to 12-in. drains. Discharge from the chambers is through 3 x 5-ft. sluice gates into a channel in a concrete wall, 8 ft. wide, running across the ends of all the coagulation basins.

Leaving the mixed-water channel the water enters six coagulation basins, each 141 x 227 ft. in plan and 17 ft. deep to the springing line of the groined-arch cover. The water will remain here three and one-half hours. In each basin there are two round-the-end concrete baffles, while between the basins are gravity walls. The floor consists of inverted groined arches, with a large amount of reinforcement placed under the pier bases. The roof, which is also reinforced over the arch crowns, is supported by 20-in. square columns spaced on 15 ft. 9-in. centers.

Three drain lines in each basin under the floor are provided with mud valves spaced closer together near the inlets so as to permit removal of sludge without draining off the water. The 3-ft. circular outlets from these basins discharge into a concrete channel running the entire length of the basins. From this channel four 48-in. connections are made to the steel influent pipe extending down the center of the pipe gallery.

FILTERS

Thirty-six filters, 49 ft. 2 in. by 35 ft. 6 in. in plan, are arranged each side of a 24-ft. pipe gallery extending upward from the ground level. The concrete boxes are supported on piers resting on a 14-in. concrete slab reinforced top and bottom for upward and downward pressure. Pier spacing here is somewhat irregular, due to pipe connections. It varies from 11 ft. 10 in. to 13 ft.

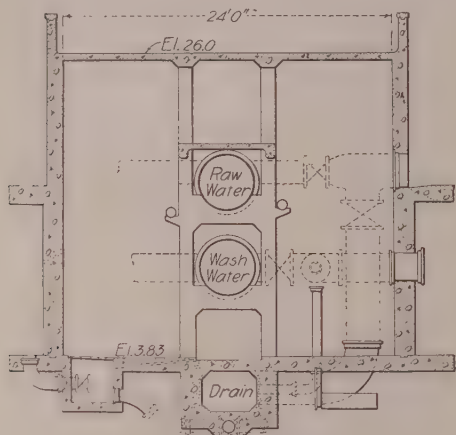


Plan of Mixing Chambers, Coagulation Basins and Filters

1 in. The depth of the clear-water space under the filters, 12 ft. from basin floor to filter floor, is limited by the load which the earth can support.

Sizes of pipe carrying the wash water and the troughs have been designed on the basis of 20 gal. per square foot vertical rise. The steel troughs are spaced 7 ft. 2 3/4 in. on centers and will discharge into a central gutter 2 1/2 ft. wide.

In the center of the filter house is to be an administration building for laboratory and offices. At one side is a hopper bottom sand bin for treatment should it be necessary to remove the filtering material from any one of the filters, inasmuch as it is recognized that some incrustation may take place. Ejector pipes are placed in each filter wall, so that the sand may be piped to the bin with a minimum of manual handling. Equipment of the filters will include the underdrains and operating



Section through Pipe Gallery

devices, none of which has yet been finally decided upon.

C. F. Schulz is commissioner of water of the city of Cleveland, reporting to the director of public utilities, C. W. Stage. R. Winthrop Pratt is consulting engineer on the filtration work, with F. H. Stephenson in charge of design and R. S. Jones in charge of construction.

TIMBER STRENGTH in its relation to botanical species was strikingly shown by one of the exhibits of the U. S. Forest Service at both the Chicago and the New York forest products shows. The display was based on the ring specification under which the Isthmian Canal Commission recently purchased large quantities of yellow pine. It provides that there must be six rings in the third and fourth inches from the heart; in lieu thereof a smaller number of rings to the inch will be accepted, provided the summerwood on the average is 50 per cent or more of the total thickness of the individual rings. Under this specification were shown side by side cross-sections of long-leaf yellow pine that did and did not pass the specifications. Similarly were pairs of sections of short-leaf, loblolly and Cuban varieties, the left-hand specimen in each case complying with the specifications and the right-hand one failing to meet them. In other words, the exhibit showed that under a proper ring specification, with the percentage of summerwood also fixed, it is unnecessary to specify the botanical species, thus eliminating one of the chief points of dispute in the inspection of yellow-pine structural timber.

Privately Owned Sanitary Sewerage System

Sewers, Treatment Plant and Pumping Station at Vincennes, Indiana, Built and Operated by Corporation on Rental Basis

LARGELY because of the low limit on the bonded indebtedness of Vincennes, Ind., the construction and operation of a sewerage system, including 40 miles of sewers, 8 to 30 in. in diameter, pumping station, treatment works and submerged outlet, were assigned to a private corporation. The new system, which was completed in November, 1913, and the method of financing were described by Robert C. Wheeler, resident engineer for Hering & Fuller, consulting engineers, the designers, at the annual meeting of the Indiana Sanitary and Water Supply Association at Indianapolis Feb. 27. The following abstract has been taken from his paper:

Vincennes, Ind., is located on the east bank of the Wabash River about 117 miles southwest of Indianapolis. The topography is very flat and the land slopes gradually downward away from the river. The area inside the city limits is about 2 3/4 sq. miles and the total difference in elevation between the extreme high and low points is only 13 or 14 ft. The population in 1910 was 14,895 and the assessed valuation about \$8,200,000. Though a railroad center and a good business town, in 1912 it did not have more than 4 or 5 miles of sanitary sewers, privately owned, and the greater part of the household waste was taken care of by means of cesspools and privies.

Owing perhaps to the fact that the city is built on a porous deposit of sand and gravel and that the public water supply is taken from the Wabash and filtered, there has not been a serious epidemic of intestinal disease in recent years.

LAYOUT OF IMPROVEMENT

In 1910, at the request of the State Board of Health, a movement was set on foot to obtain a sanitary sewerage system, and plans and specifications were made involving 60 miles of sewers, but owing to the difficulties in financing and other reasons the mileage was cut to about 40 miles, which cover the city very well, so far as it is built up at present. The system is designed to have ample capacity, so that with future extensions it will serve the city when it shall have a population of 30,000, without paralleling existing sewers. Pumping station and outlet are about 1700 ft. downstream from the city limits, on a site which will be suitable for disposal works should further treatment become necessary. The work was begun in 1912.

The population of the larger towns and cities on the Wabash River watershed, above and including Vincennes, is about 175,000, and the dry weather flow at Vincennes is approximately 2000 cu. ft. per second. This is a dilution of 11 or 12 cu. ft. per second for each 1,000 of population located in the towns and cities of the watershed, which presumably will sooner or later have fairly complete sewerage systems. This ratio is considerably in excess of that legally established in the case of the Chicago Drainage Canal, viz., 3 1/3 cu. ft. per second per 1000; but care has been taken to prevent any possible nuisance at the outlet and to protect the people along the river below the outlet in case of an epidemic. There are no large communities for some

10 miles below the outfall, and no communities taking water supply from the Wabash for more than 30 miles. Hence the freeing of the sewage from coarser solids and distributing it in the river in such a manner as not to cause local nuisance will probably be sufficient treatment for many years to come. It seemed advisable, however, as an especial safeguard to the people below in case of an epidemic in Vincennes, to provide apparatus for applying a solution of hypochlorite of lime to the screened sewage when needed.

TREATMENT AND DISPERSION

The sewage is passed through two sets of bar screens having clear openings of 7/8 in. and 7/16 in., to remove the coarser solids which would tend to injure the pumps, clog the distributing outlet, collect and putrefy on the river banks, or be offensive in the flowing stream. A detention period of ten to fifteen minutes or more is provided for. This will give time for the hypochlorite to react and will generally allow the sedimentation of any particles which are so large that they would readily clog the orifices in the outlet pipe.

It is proposed to use from 75 to 125 lb. of the commercial hypochlorite of lime to 1,000,000 gal. of the partially clarified fresh sewage, depending upon the character of the sewage. The screenings will be burned in an incinerator in the pumping station.

The distributing outlet consists of a 24-in. cast-iron pipe, extending into the river about 300 ft. In the last 120 ft. are located five double outlets 6 in. in diameter and about 30 ft. apart. The purpose of this type of outlet is, first, to discharge the sewage under the water even in time of extreme low stage, insuring thorough mixing and preventing nuisance, and, second, to conduct the sewage to a point in the river where the current is swift enough to prevent sedimentation and the formation of bars or deposits of sludge along the shore.

VENTILATION

For a number of reasons, including the flooding of some of the streets in time of high stage in the river and the sifting in of gravel at all times, due to the character of the street surfaces, it was not practicable to ventilate the sewers through perforated manhole covers. The method recommended was that of omitting the trap in each main house connection and ventilating the sewers through the main house lateral and its connection to the soil pipe extending above the roof. This seems to provide the best method of securing clean and sanitary sewer connections. If each separate connection to the soil pipe in the house is trapped as usual, there is no real reason for a trap in the house connection to the sewer.

There are about 260 250-gal. flushtanks, one at the head of nearly every sewer line. The amount of water used is controlled by a flow-regulating device containing a hard rubber disc with an orifice of such a size that under the average pressure in the mains enough water will be discharged into the tank to flush it once in twenty-four hours.

Flushing the larger pipes, which will run at only a small fraction of their capacity for the first few years, can be effected by putting temporary stop planks in the man-holes, thus backing up the sewage until sufficient head is obtained to produce a velocity to remove deposits.

PRIVATE FINANCING

Ordinarily sewers are constructed in Indiana under one of three plans—appropriation by council from the tax budget, assessing the property benefited, or issuing bonds.

The estimated cost of the system was \$334,500. This eliminated the first method, which is only practicable for short lengths of sewers such as laterals. Assessment was considered inadvisable or impracticable under local conditions where public opinion was somewhat at variance as to the relative importance of sanitary sewers, storm drains, flood protection, street pavements, etc. The third method would not have provided enough money, since the bonded indebtedness of Vincennes was limited to 2 per cent on an assessed valuation of about \$8,200,000, which would have yielded only \$164,000.

The plan finally evolved is as follows: The common council granted an association incorporated under the laws of the State as the Vincennes Sewer Association a franchise to build, operate, maintain, and extend a system of sewers which was fully defined both as to extent and quality by plans and specifications which were made part of the franchise. The city agreed to provide compensation to the sewer association in one of three ways, at the option of the city, paying an annual rental, purchasing the system at a price decreasing each year according to a schedule stated in the franchise, or allowing the sewer association to operate as a public utility, charging patrons for the services rendered according to a schedule included in the franchise.

The first, or rental basis, is the program which is being followed at present and which will probably continue to be followed, unless the city finds it more advantageous to raise the necessary money and purchase the system.

The third method was introduced to protect the sewer association in case the city did not purchase the system and failed to pay the rental, taxes, insurance, operating expenses, etc. It comes into operation automatically upon the continued failure for sixty days on the part of the city to pay any of these.

In the first two cases the cost of maintenance and operation is borne by the city, which is also to keep the system properly insured. In the third case the city assumes no obligation and has no different relation than that maintained with any other public utility, maintenance and operation being borne by the company. With this franchise as a basis bonds were issued by the association and were signed by the Mayor merely to identify the bonds as being of the issue which they were represented to be.

The annual rental is such that it will pay 6 per cent interest and retire all the bonds in twenty-five years. Thus, the selling price decreases each year until at the end of twenty-five years it is equal approximately to the rental due at that time. Upon the payment of this sum the title to the system passes to the city without further payment.

The annual rental is \$26,425, to be paid in equal semi-annual installments dating from Jan. 1, 1912, except that provision was included that the first payment on July 1, 1912, should be \$8,500, provided the system were half completed by that date, or, if not, such a proportion of \$8,500 as the amount of work done was of 50 per cent of the entire system, the remainder of the \$8,500 being retained until 50 per cent of the work was completed.

Assuming maintenance, pumping, operation, insurance, etc., to be \$5000 per year, in addition to the rental, the annual cost will be \$31,425. On the basis of the present population of 15,000, the per capita annual cost will be a trifle over \$2. This includes not only sewer service but also an amount to be applied to the purchasing of the system. That is to say, at a cost of a little more than \$2 per capita annually for twenty-five years the city may secure sewer service and at the end of that time own the system in a well-maintained condition and of a size and extent which will not have to be paralleled while the population is doubling in amount.

RECOMMENDATIONS

This is believed to be the first sewer system in Indiana so financed, but the results on the whole have been and promise to remain very satisfactory.

When proceeding under this method especial care should be taken in drawing the plans and specifications to give them proper flexibility and to define clearly the exact position of the city as regards inspection, engineering, and overseeing construction. In the Vincennes work the city's only representative on the ground was the writer, as resident engineer, acting under the board of public works. His duties were to act as adviser to the board in regard to suggestions as to changes in the plans, have general oversight of the work and pass on materials and workmanship, and make a final inspection of the system and recommend its acceptance or rejection.

Estimates of cost upon which payments during construction were based were made by George W. Sturtevant, of Chicago, acting as engineer for the sewer association.

The contractors, Stewart Sheets & Company, furnished lines and grades according to the contract drawings or supplementary drawings furnished by the resident engineer, and at the completion of the work furnished the city with record plans of the system as constructed. While this arrangement was reasonably satisfactory, it would probably be advisable as a rule for the city to have more complete control by furnishing lines and grades, keeping all records, making estimates of cost, and maintaining more thorough inspection.

With these points carefully considered, this method of procedure may help to solve the problem for other towns where otherwise a lack of funds may prohibit the construction of the whole sewer system at once, and where, as at Vincennes, a relatively expensive outfall may put too heavy a burden on the first section to permit proceeding by sections under the assessment plan.

RELATIVE WATER CONSUMPTIONS
In Louisville, Ky., for 1913 were as follows: Industrial consumption, 3,672,240,306 gal. per year; domestic consumption, 5,651,774,735 gal. The domestic consumption was 66 gal. per capita daily.

Erection of Little River Viaduct

Tall Tower Erected in Temporary Position and Moved Horizontally to Place

THE Little River viaduct of the Trans-continental Railway is 192 miles from Moncton, Canada, and is a single-track plate-girder structure with 40-ft. towers and 60-ft. connecting spans. It has a total length of 1242 ft., including a river span of 100 ft. and end spans of 80 ft. 9 in., and is 110 ft. high. In order to permit the erection of the long-span girders and their towers to be effected by the short



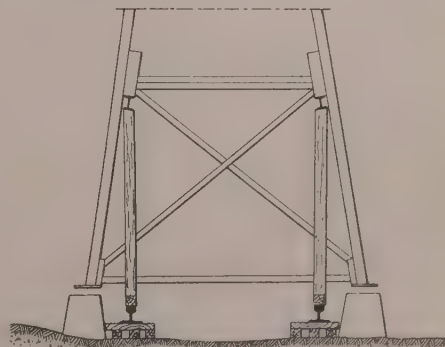
Erecting Tower Column with Derrick

boom of the derrick car on the completed portion of the structure, the unusual expedient was successfully adopted of erecting a tall tower in temporary position and moving it as a unit longitudinally to permanent position.

ERECTING TOWERS

Materials were delivered on a distribution track on the surface of the ground, and all of them were unloaded, where required, by the derrick car at grade. The derrick car also erected all of the steel except the first bent, which was too far from the first position of the car on the abutments for its reach, and was therefore erected by a stiffleg derrick.

The first tower for the 100-ft. span was



Tower Shored Up on Skid Rails

625 acres and has a frontage on San Francisco Bay of 21-3 miles. It is accessible both by land and by water, being located at Harbor View, a tract which lies between the Presidio and Fort Mason, Government military posts. A portion of these Government reservations have been loaned to the directors for exposition purposes. The ground occupied by the main building is relatively flat with a slight slope from its southerly boundary toward the water front. The surrounding hills, on which are the finest residences of the city, form a picturesque background to this impressive natural amphitheater. The view of the harbor from the site is unexcelled.

Prior to the commencement of construction a portion of the site was occupied by an inland basin of water, bounded by a sea wall running east and west along the present northern extremity of the grounds. It was necessary to fill this basin, as well as the low lands lying in that portion of the Presidio devoted to exposition use. This fill was made hydraulically; 1,300,000 cu. yd. of material were placed in the basin, and approximately 400,000 cu. yd. in the Presidio grounds.

This work was done very carefully, and a fill of approximately 70 per cent sand and 30 per cent silt and sea deposit was the result. Construction activities of all sorts have proceeded upon this fill—a remarkable fact when it is remembered that usually considerable difficulty is experienced with new fills.

There is some settlement of the fill going on, but the only factor to be considered in this connection is in the matter of roads over the filled area, since it has been decided to support all structures and heavy exhibits by means of piles. The settlement curves indicate a gradual reduction in the amount of subsidence, and there is every reason to believe that by the time roads are ready to be paved all settling and compacting will have taken place.

During the process of filling, close investigations and tests were conducted. Samples were taken of the pipe discharge at all times, and when it was found that its character was not desirable, the dredgers were moved to other locations in the bay where the banks were thought to contain better material. In this way the results obtained were satisfactory in every respect. The total cost of this filling was as follows: Harbor View, 1,300,000 cu. yd., \$220,000; Presidio lands, 400,000 cu. yd., \$81,000.

There was a vast amount of work in acquiring the property now comprising the exposition grounds. Outside of the Government reserve, 76 city blocks were obtained. This work of acquisition was actually commenced about Feb. 1, 1912, and was practically completed by Feb. 15, 1913.

The property was either bought or leased, and portions of it were occupied by improvements of various sorts. During the period of acquisition leases and deeds were executed by 175 parties, owning nearly 200 separate parcels of land. There was involved

the purchase and removal of about 400 dwellings, barns and other improvements, which cost the exposition in the neighborhood of \$407,000, and in the majority of these cases rentals were paid aggregating \$300,000.

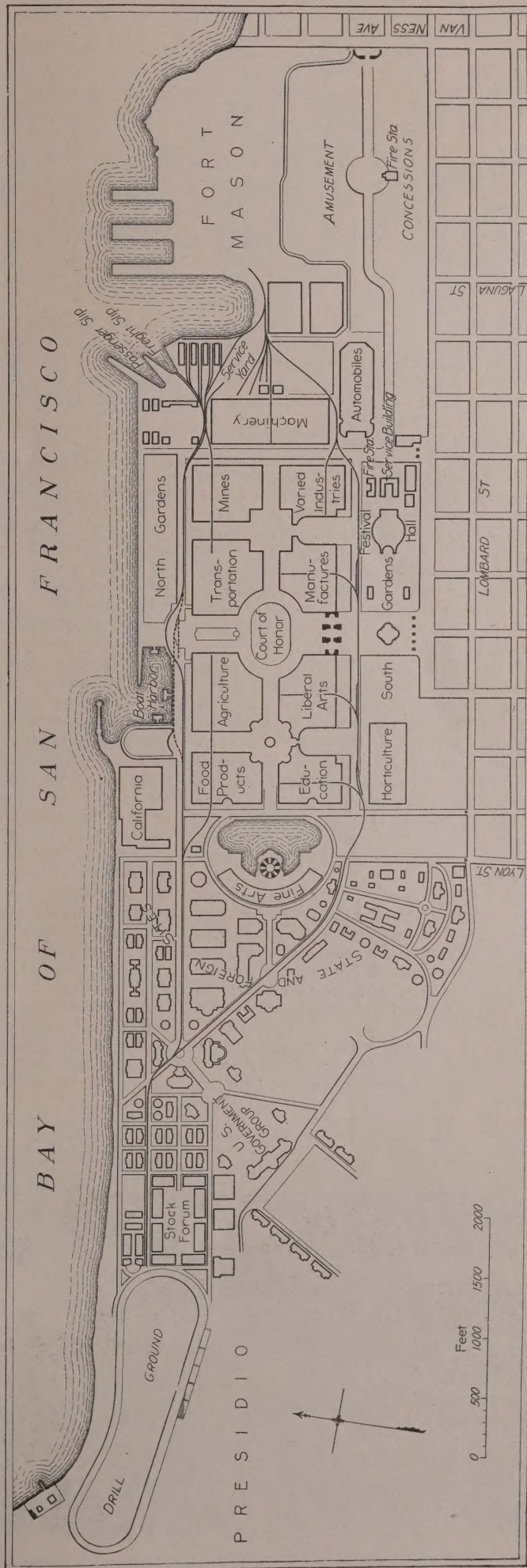
A number of improvements were sold by the exposition company to the highest bidder, privately or at auction, and the total sum netted by the company was not to exceed \$30,000. About forty dwellings were moved to other sites by the purchasers and the remainder were wrecked and disposed of piecemeal.

Wherever the exposition company could not lease the property it was found necessary to purchase, and in this manner were acquired seventeen parcels of land, one of which was the plant of the Fulton Engineering & Shipbuilding Company, an old-established firm of San Francisco. The total expenditure for acquiring lands outright was \$305,000, and the exposition now owns in fee simple 12.26 acres of land.

The total cost of the site, to cover its use up to Jan. 1, 1917, will amount to \$1,000,000. The acreage to be used is divided as shown in the table.

BLOCK PLAN

The main group of exposition palaces, covering approximately 43 acres, while not under one roof, gives the general impression of being a single unit. On the main axis, running north and south, are the main entrance, the great tower and the court of honor. The transverse axis, which termi-



General Plan of Panama-Pacific Exposition Grounds, Showing Main Palaces, Courts, Gardens and State and Foreign Sites

DISTRIBUTION OF EXPOSITION ACREAGE

	Acres
Concession district	69.2
Railway yards, wharves and docks	17.1
Exhibit palace site proper	217.3
Street-railway terminals	2.3
State pavilion sites	42.3
Foreign pavilion sites	49.7
Aviation field, drill grounds and racetrack	37.7
Live-stock section	24.3
Life-saving station	1.1
Proposed U. S. Government exhibit	12.7
Unappropriated at westerly end	10.3
Total area for definite purposes	484.0

DIMENSIONS AND COSTS OF BUILDINGS, PANAMA-PACIFIC EXPOSITION

Palace	Size of building, ft.	Area of building, sq. ft.	Volume of building, cu. ft.	Average height of building, ft. and in.	Total cost.	Floor area	
						Sq. ft.	Cost per sq. ft.
Agriculture	579 x 639	328,633	20,634,000	62 6	\$425,610	328,633	\$1.30
Education	394 x 526	205,100	14,053,000	68 6	304,263	205,100	1.48
Festival Hall .....	.....	.....	.....	.....	270,000	57,400	4.70
Fine Arts .....	.....	126,000	.....	.....	580,000	204,325	2.84
Food Products	424 x 579	236,690	15,609,000	66 0	342,551	236,690	1.45
Horticulture .....	.....	195,000	.....	.....	341,000	201,000	1.70
Liberal Arts	475 x 585	251,300	16,038,000	64 0	344,180	251,300	1.37
Machinery	367 x 967	363,600	38,000,000	103 0	659,665	369,600	1.78
Manufactures	475 x 552	234,000	15,650,000	67 0	341,069	234,000	1.46
Mines and Metallurgy	451 x 579	252,000	16,199,000	64 0	359,445	252,000	1.43
Transportation	579 x 614	314,000	20,413,000	65 0	481,677	314,000	1.53
Varied Industries	414 x 541	219,000	14,648,000	67 0	312,691	219,000	1.43

nates in the machinery and fine arts palaces on the east and west respectively, passes through two subordinate but none the less important courts—the eastern court or Court of Abundance and the western court or Court of the Four Seasons.

The climatic conditions of San Francisco were considered in arranging the exposition plan. Though the climate is mild and equable throughout the year, there are frequently high winds from the west and occasionally from the north. San Francisco is also subjected to more or less fog. The type of plan adopted was chosen after careful study of these atmospheric conditions. It is believed that the interior courts and the large area south of the main group will provide suitable retiring spots at times when the winds prevail.

The amusement concessions lie east of the main group, while to the west are located the sites for the State and foreign pavilions, with a suitable situation for the U. S. Government pavilion. The latter is located on Government territory and in all probability will be a permanent building, available for the use of the Government in connection with the Presidio. Further west are located the stock exhibit, racetrack and drill grounds.

The avenues or thoroughfares surrounding the main group are broad and straight and they will be attractively bordered with foliage, enhancing the beauty of the buildings. The roads in the States and foreign district have been laid out to conform to the topography and site boundaries of that section.

From an internal traffic standpoint, the plan is unquestionably a happy solution of the exposition problem in that the distances

to be traveled are reduced to a minimum. In other large expositions the main exhibit palaces were 300 to 400 ft. apart, while in the present exposition this distance has been reduced to 150 ft.

Cape Cod Canal

Completion of \$12,000,000 Channel and Approaches Connecting Cape Cod Bay and Buzzards Bay

THE Cape Cod Canal reduces the length of the outside water route from Boston to New York from 402 miles to 260 miles and has just been completed at a cost of about \$12,000,000. About 25,000 vessels per year go around Cape Cod, and it is expected that they will provide a canal tonnage of 25,000,000 tons per year. The improvements include about 8 miles of canal channels, 100 ft. wide on the bottom with a depth of 25 ft. to mean low water and side slopes of two to one; 5 miles of approaches with bottom widths of 250 and 300 ft., and 3000 lin. ft. of breakwater. Its construction involved an excavation of 17,000,000 yd. of material and has been accomplished in about four years. A description of the canal and the methods of construction was published in the Engineering Record of July 24, 1909, page 92, and July 30, 1910, page 133. The accompanying picture, looking toward Cape Cod, shows in the foreground a dipper dredge with a 10-yd. bucket and a capacity of 13,000 yd. a day.

William Barclay Parsons, of New York, is the chief engineer of the canal and the Degnon Cape Cod Canal Construction Company was the contractor.

Large Astronomical Telescope for Victoria, B. C.

ANNOUNCEMENT was recently made at Ottawa that the Dominion government of Canada would establish an astronomical observatory at Victoria, B. C., to be equipped with a telescope and other apparatus for supplementing the Government astronomical work heretofore done at Ottawa. The details of the equipment to be installed have not yet been announced, but a site has been selected at Saanich Hill north of the city proper, and it is stated that the contracts for both the lenses and the mechanical parts have been awarded.

The telescope, which is to have a 72-in. reflector 12 in. thick, will have a focal length of 108 ft. and will be carried in an open steel frame or tube 30 ft. long and 90 in. in diameter. The weight of the mirror to be "floated" on a system of levers will be about 2 tons, and the moving parts of the telescope will total about 8 tons. The housing is to be a circular building of steel construction with walls 30 ft. high and surmounted by a revolving dome 60 ft. in diameter. The optical parts of the new telescope are to be supplied by the John A. Brashear Company, of Pittsburgh, Pa., and the mountings by the Warner & Swasey Company, of Cleveland, Ohio.

Varieties of Estimates

CLASSIFICATION of estimates suggested by Allen Hazen, consulting engineer, are given as follows in the "Reclamation Record":

1. Preliminary estimates, being estimates made in advance of the preparation of detailed plans and specifications for the purpose of discussing a project for deciding as to its adoption, and for making the necessary financial arrangements for carrying it out.

2. Detailed estimates, being estimates based upon detailed plans for the execution of the work, and usually made shortly before bids are asked for the particular work covered, or in advance of undertaking to carry it out by day labor.

3. Final estimates, being the estimates to the contractor at contract prices for the actual work done. The term "final estimate" may also properly be applied to a statement of the cost of a completed work based upon actual expenditures.



Cape Cod Canal in Its Final Stages, Showing Dipper Dredge with 10-Yard Bucket in Foreground

Letters to the Editor

Design of Eccentrically Loaded Concrete Members Reinforced in One Face

SIR: Under the caption "Design of Reinforced-Concrete Retaining Walls" in your issue of Jan. 17, 1914, page 86, Donald M. Becker presents a treatise which purports to be, primarily, a "cut-and-try" method for the dimensioning of eccentrically loaded concrete members reinforced in one face. He notes the lack of requisite tables or graphs in the so-called texts for the direct framing of such members and offers his method as an evasion of the cubic equation.

It may be safely stated that the cubic equation cannot be evaded in the development of a perfectly general formula for the design or analysis of reinforced-concrete members resisting combined axial loading and bending. However, for the particular class of concrete members referred to by Mr. Becker—statically determinate members resting such combinations of axial compression and bending forces as develop tension in the one-face reinforcement—a fairly direct analytical method avails without resort to the cubic.

Referring to the accompanying figure, this method may be developed where M denotes the bending moment measured about the point midway between the steel and the compression face; N , axial load; d , net depth of section; b , breadth of section; A , sectional area of steel; p , steel ratio, A/bd ; f_c , unit edge compression in concrete, f_s , unit tension in steel; n , moduli ratio; k , ratio of neutral-axis depth to d , and R , bending-resistance coefficient.

If the tensile resistance of concrete is considered nil there obtains from the summations of parallel forces

$$N - f_c b k d / 2 + f_s A = 0 \quad (a)$$

and of moments

$$M - f_s A d / 2 - f_c b k d (d/2 - k d / 3) / 2 = 0 \quad (b)$$

so that with the straight-line stress relation

$$f_s / f_c = n (1 - k) / k \quad (c)$$

there results a value of the steel ratio, p , in terms of unit stresses

$$p = A / b d = k f_c / 2 f_s - N / b d f_s \quad (d)$$

and a value of the bending-resistance coefficient, R

$$R' = M / b d^2 = f_c k (1 - k / 3) / 2 - N / 2 b d \quad (e)$$

Now if N is given a zero value in these two equations the conditions obtain as for a member resisting flexure only. Thus the steel ratio, p , and the bending-resistance coefficient, R , for a rectangular beam, reinforced in one face, may be expressed in like terms:

$$p = k f_c / 2 f_s \quad (f)$$

$$R = f_c k (1 - k / 3) / 2 \quad (g)$$

Thus we may write

$$p' = p - h / f_s \quad (1)$$

$$R' = R - h / 2 \quad (2)$$

in which the term h is used merely as a unit measure of the intensity of the axial loading and has the value

$$h = N / b d \quad (h)$$

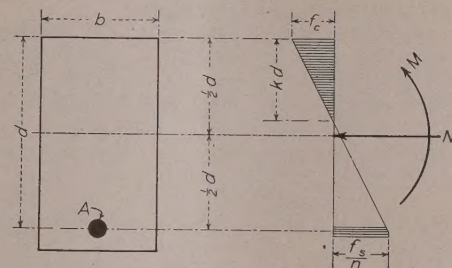
Equation (1) indicates that a smaller ratio of reinforcement is necessary to develop given working stresses in members resisting combined axial compression and bending than in members resisting bending only, and equation (2) indicates that

with this reduced steel ratio a somewhat reduced value of the coefficient of bending resistance obtains. For each the reductions are directly proportional to the intensity, h , of the axial compression.

With these two formulæ and an ordinary table of rectangular-beam functions relief from the cubic may be had and the design or analysis of this particular class of eccentrically loaded concrete members expedited.

The accompanying table gives values of the steel ratios and bending-resistance coefficients for rectangular concrete beam sections reinforced in tension only for combinations of unit stresses in pounds per square inch ranging downward from set working maximums of 16,000 lb. tension in steel and 650 lb. edge compression in concrete. It is based on a modulus ratio of 15.

Applying this method to the determination of required reinforcement in Mr. Becker's hypothetical L-shaped retaining



wall 21 ft. high, which at a section of 26.5 in. net depth resists an axial load of 6000 lb. and a bending moment of 517,250 in.-lb. each per linear foot of wall.

$$R' = M / b d^2 = 517,250 / (12 \times 26.5^2) = 61 \text{ and}$$

$$h = N / b d = 6000 / (12 \times 26.5) = 19$$

Hence

$$R = R' + h / 2 = 61 + 19 / 2 = 70.5$$

For this value of R in the table f_s and f_c are respectively 16,000 and 500 lb. per square inch and p is 0.0050, so that from equation (1)

$$p' = p - h / f_s = 0.0050 - 19 / 16,000 = 0.0038$$

and the requisite sectional area of reinforcement per linear foot of wall

$$A = p' b d = 0.0038 \times 12 \times 26.5 = 1.21 \text{ sq. in.}$$

which checks Mr. Becker's "cut-and-try" finding.

If the magnitudes of axial load and bending moment were such that the value of R , found as above, exceeded 108, the right-hand portion of the table would apply.

Conditions seldom warrant the construction of L-shaped retaining walls 21 ft. high.

TABLE OF RATIOS AND COEFFICIENTS

$f_s = 16,000$			$f_c = 650$		
f_c	p	R	f_s	p	R
650	0.0077	108	16,000	0.0077	108
625	0.0072	101	15,000	0.0085	111
600	0.0068	95	14,000	0.0095	115
575	0.0063	89	13,000	0.0107	119
550	0.0058	83	12,000	0.0122	124
525	0.0054	77	11,000	0.0140	129
500	0.0050	71	10,000	0.0161	134
475	0.0046	65	9,000	0.0188	140
450	0.0042	60	8,000	0.0224	146
425	0.0038	55	7,000	0.0270	152
400	0.0034	50			
375	0.0030	45			
350	0.0027	40			
325	0.0024	35			
300	0.0021	31			

What is usually considered their limiting economic height is, say, 10 or 12 ft., and at this height ordinary beam formulæ give results quite commensurate with the exactness possible in the calculation of their loading. Use of Mr. Becker's example is here made for brevity in illustrating the application of theory only.

The formulæ given are, however, of considerable usefulness in the design of arch spandrel walls carrying overhanging walks, horizontal struts of long span, area walls with superimposed loads and slab elements of box-shaped culverts and conduits.

These formulæ and the table have been used occasionally by the writer for several years. The calculation of a table to fit other limiting stress units may be easily made by the employment of equations (f) and (g).

CHARLES W. MARTIN,
Bridge Division.

St. Louis.

To Obviate the Opening Up of Pavements

SIR: The Engineering Record of April 18 contained an editorial suggesting a means of obviating the tearing up of city pavements. The subject is a serious one, without doubt, but perhaps not as serious as it appears to be.

It is true that our pavements are cut up a great deal, sometimes almost as soon as laid and before the contractor is paid for them, and these openings are obstructions to traffic much in evidence. The paved area of streets in Manhattan at the beginning of 1913 was about 9,345,000 sq. yd., and the total area of paving laid over trenches in 1913 was about 196,000 sq. yd., or a little more than 2 per cent. In 1912 about 10 per cent of the mileage of paved streets in Manhattan was repaved, so that in any one year a very large proportion of our streets appears to be torn up. It is now the policy, however, to notify all property owners and corporations to make all necessary repairs and additions before repaving is begun. This reduces the amount of subsequent cutting.

In regard to your suggestion, the average contract price for granite-block paving is about \$4.50 per square yard and for sheet asphalt \$2.50 per square yard, both inclusive of concrete foundation. Now, 2 per cent of \$4.50 is 9 cents per square yard of the total paved area, which is the cost per annum to the community. The cost of the suggested slabs is estimated at \$2.70 per square yard for the concrete slab alone, without, I take it, cost of hauling or of wearing surface on all streets to be paved hereafter; in other words, an increase in cost of original paving of about \$1.80 per square yard. This added cost does not, however, get rid of the obstruction to traffic at all, but would, in fact, add to it by blocking the entire width from curb to rail.

A much better solution of the difficulty would be to put all service lines of ducts, water and gaspipes under the sidewalks, connections being made to the mains only at street intersections. Openings in the sidewalk would cause much less interruption to traffic and the restoration of pavement would cost about \$1.80 per square yard of concrete sidewalk.

This solution of the problem has already been adopted in some European cities, I believe, and could easily be used in New York, especially uptown where vaults are

not so common. Where those exist, the city can order the changes, putting the expense either on the holder of the vault permit or on the subsurface corporations. A space of not more than 3 ft. in depth would be required to accommodate the service lines and gradually some order would be evolved from the awful chaos shown now whenever a street is opened at an intersection.

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Assistant Engineer, Bureau of Highways,
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Small Contracts for Large Works

SIR: In the editorial entitled "Small Contracts for Large Works" in the Engineering Record of May 9 an important problem in the execution of large contracting works seems to be left out of consideration, and your remarks seem liable to leave an impression so far at variance with the general experience of contractors that we should like to ask you for space to present the other side of the question.

One of the most important services rendered by the general contractor on large construction contracts is the planning and control of the various parts of the work and the sequence of operations in such a way that every part of the work and every trade employed shall work in co-operation and harmony—that each operation be so arranged that it does not delay another and that materials, men, etc., for each operation be on hand when wanted. Every job needs one administrative head in full control of the work to insure this end being attained. If there is a general contractor that has this duty to perform, any financial loss due to errors or bad management falls upon him; but if the engineer assumes this task, the monetary loss due to any failure or mistakes falls not upon him but upon both the owner or public authority for whom the work is done and the various contractors employed upon the work.

In cases where the engineer himself has had administrative experience and is able to assume the direction of affairs—as is undoubtedly the case in the Baltimore job cited—there is no question that he can well assume these responsibilities; but as a general rule the engineer's ability lies more in the scientific knowledge of methods of design and processes to be carried out and in the application of them to the special conditions of the work in hand than in the planning out of the sequence of the various operations involved in the execution of the contract and their co-ordination. The latter is especially the first duty of the general contractor. In assuming this duty the engineer is taking upon himself a very large responsibility, one which is not usually considered part of his duties. If in the Baltimore case the whole of the work proceeded smoothly, and each contract dovetailed into the others without delay or friction of any sort, and a large saving in cost effected, it is evident that in this case the procedure was justified by the results; if other engineers are able to perform similar work with equal efficiency there is no reason why they should not do so, and their clients will be the gainers. But if the engineer fails to plan the work satisfactorily, trouble and confusion are bound to result; vexatious delays and claims for extras will arise, and not only the client but also the contractors and subcontractors will suffer. We could cite many instances from our own

experience of large work being let piecemeal with unhappy results. A rush job of ours was recently held up for three weeks because the concrete foundations could not be poured until the templates for certain large machines were made and furnished to us. Machinery often arrives weeks after it is promised or else is delivered too soon. A job of ours this winter was held up for several weeks because two isolated steel columns which were part of a large separate contract for structural steel had not arrived. These are but typical of many others.

The consulting engineer's training and experience do not usually fit him for the assumption of this important part of the contractor's duties, although there are many notable exceptions to this, and on some of our jobs the engineer's co-operation in this department has been most helpful. In a majority of cases where the co-ordination of operations and the control of a number of sub-contractors have been taken out of the general contractor's hands, friction, delays and unnecessary expense of all kinds have been the result.

It is very seldom that such large savings are made by a subdivision of the work as in the Baltimore case, and it is not clear that more than \$120,000 was saved thus in this case, as an item of \$203,000 in the original bids appears to have been for royalties which were never paid.

No one grudges the smaller men their share of the bid work. No one objects to working with others under proper control; but we should like to affirm most emphatically our conviction that the control of operations in large contracts should be vested in the parties who by training and experience are best fitted to assume the responsibility, and we believe that in nearly every case this party is the general contractor.

ABERTHAW CONSTRUCTION COMPANY,

By Leslie H. Allen.

Boston.

Value of a Library in an Engineering Office

SIR: The article in the Engineering Record of April 25, page 479, by Louise B. Krause, on the "Value of a Library in an Engineering Office," refers mainly to firm libraries. The young engineer, working for himself along similar lines, can build up a valuable library and index while gaining his practical experience. The index thus made, while not nearly so complete, is more valuable than one that could be bought.

The writer is in favor of some form of decimal classification. With an index of this kind one can extensively subdivide the topics of interest to himself, while the subjects of only ordinary interest can be placed under general headings. For instance, the writer has grouped irrigation, drainage, flood control, and navigable waterways under 8.1, 8.2, 8.3 and 8.4 respectively. Should he later turn to this branch of engineering, it would be comparatively easy to go through the list of references and make such subdivisions as necessary by adding to the card numbers. It seems desirable to make subdivisions as needed and not try to cover the whole field of one branch of engineering at the start. One can save time and also develop a subject better after he is interested in it.

The writer believes the young engineer

should completely index and have bound the technical magazines for which he subscribes. Complete files of the transactions of the various engineering societies may usually be obtained at some public library for the purpose of indexing. Many pamphlets and books may be added to one's library merely for the asking. The indexing of text books is of little value, as the information they contain can usually be found without much difficulty.

Aside from the value of the index in itself, the making of it will encourage intensive and extensive reading. Many young engineers, fresh from college, are prone to think they know all of engineering, and neglect to keep up with the work for which they are trained. In a few years they will be the leading complainers about being underpaid. A good way to keep out of this class is to take the leading technical magazines in one's branch of engineering, get access to the transactions of the engineering societies and index everything read. One must read closely to index correctly.

Dallas, Texas.

W. M. E.

Filters in Bubbly Creek, Chicago

SIR: Underdrains for the filter plant at the Union Stock Yards in Chicago, filtering the highly polluted water of Bubbly Creek, are of the Norwood type, the clear opening in the slotted 4-in. arms of the tees spaced on the corners of 6 x 10-in. rectangles being 0.11 per cent of the sand area. Brass air pipes, $\frac{3}{8}$ in. in diameter, spaced on 4-in. centers and perforated with holes $\frac{1}{100}$ in. wide and $\frac{1}{2}$ in. long, are laid over the tops of three 3-in. layers of gravel, $\frac{1}{8}$, $\frac{3}{8}$ and $\frac{5}{8}$ in. in size. The 30 in. of 0.38-mm sand, having a uniformity coefficient of 1.65, is uniformly washed by water applied under 6-lb. pressure. Details were given in the Engineering Record of Dec. 12 and 19, 1908, pages 659 and 703. Results of two years' operation and changes in plant appeared Sept. 24, 1910, on page 340.

During washing the water over the sand surface is not drained, as the butterfly valves controlling the influent would open, letting in treated water. Air is applied for two minutes, air and water combined are admitted for three minutes and then water is applied until clean for about three minutes. Water is then turned into the air system to free it of entrained air, a procedure used with success in case a filter becomes airbound during filtration.

Once in a long time mud patches have been noted, but they are removed as soon as found. While the sand depth has not been measured, none has been added during the six years' life of the plant. No formations have been found in the underdrains since we began the use of aluminum sulphate as a coagulant and bleach as a germicide. Explorations indicate that the gravel bed remains practically level.

C. A. JENNINGS,

Superintendent, Bubbly Creek Filters,
Chicago.

MORE THAN 1,000,000 TREES are being transplanted by the New York State College of Forestry at Syracuse on the 100-acre experiment station just south of the city. These trees will be used for educational work with students and for experimental purposes and then sold to planters throughout the State through the State Conservation Commission.